Valuing the Tarkine:

A Systematic Quantification of Optimal Land Use and Potential Conflict Compromise

by

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Declaration of originality

This thesis contains no material which has been accepted for a degree or diploma by the University or any other institution, except by way of background information and duly acknowledged in the thesis, and to the best of my knowledge and belief no material previously published or written by another person except where due acknowledgement is made in the text of the thesis, nor does the thesis contain any material that infringes copyright.

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The research associated with this thesis abides by the international and Australian codes on human and animal experimentation, the guidelines by the Australian Government's Office of the Gene Technology Regulator and the rulings of the Safety, Ethics and Institutional Biosafety Committees of the University.

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Abstract

Ecosystems continue to deplete as global demand for natural resources force land use change and cause environmental conflict. Optimal land use that considers both the significance of ecosystems and the sustainable human consumption of natural resources is required. Thus, the primary aim of the thesis was to develop an integrated approach to resolving land use conflict using the Tarkine as an exemplar. Land use change and environmental conflict are influenced by complex socio-economic factors and necessitate systematic resolution practices that address deep disagreement on values. This thesis fills a research gap by providing a systematic quantification of optimal land use and potential conflict compromise that integrates attitudes, preferences and economic values.

The spatial patterns of optimal land use in the Tarkine are established using two approaches: a) the *a priori* approach to determine the different levels of significance and the relative worth of values and b) the *a posteriori* approach to determine the importance of values to people. The heritage importance of conservation values in the Tarkine was determined using their level of significance, legal recognition of importance, area in relation to Tasmania, Australia and the world, rarity, and distinctiveness. Aboriginal cultural heritage, coastal interdigitation, rainforest river landscapes and wild Dasyuridae habitats may meet criteria for World Heritage listing. Aboriginal cultural heritage, biodiversity and wilderness values may increase in the future. The international significance of the Aboriginal cultural landscape in the Tarkine has not been fully determined.

Cost-benefit analysis, variable discount rates, time frames and output multipliers were used to calculate economic values. There is high economic potential for carbon and tourism development in the Tarkine, and localised potential for mining. However, the application of output multipliers changes the results creating large areas of forest with greater economic value than tourism and carbon combined.

A novel reciprocal triangulation of data using attitudes and participant mapping found that conflict is multidimensional; that informed discussion of values leads to increased willingness to compromise potential outcomes; and, that variation in such willingness is predictable. A practical example suggests a way forward to resolve conflict in the Tarkine through applying a second iteration of the research findings to quantify future trade-offs and advance conflict resolution processes.

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List of Abbreviations

AADT	Annual average daily traffic
ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences
ABC	Australian Broadcasting Corporation
ABS	Australian Bureau of Statistics
ACCU	Australian Carbon Credit Unit
AHC	Australian Heritage Council
ANOVA	One-way Analysis of Variance
ANU	Australian National University
APCA	Arthur-Pieman Conservation Area
APV	Adjusted present value
ARTC	Australian Rail Track Corporation
ASX	Australian Securities Exchange
AWU	Wetland (undifferentiated) TasVeg 2.0 vegetation community code
BCR	Benefit-cost ratio
CA	Annual carbon growth
CARRS	Comprehensive, Adequate and Representative Reserve System
CBA	Cost-benefit analysis
CCA	Cradle Coast Authority
CFI	Carbon Farming Initiative
CHC	Circular Head Council
CP	Carbon trading price

CRA	Comprehensive Regional Assessment
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CSR	Corporate social responsibility
CVN	Current visitor nights
DF	Degree of freedom
DPIPWE	Department of Primary Industries, Parks, Water and Environment
DRM	Deep Red Myrtle
EBPC	Environmental Protection and Biodiversity Conservation Act
EMDA	Economic and Market Development Advisers
ERF	Australian Government Emissions Reduction Fund
ESA	Equivalent standard axel
ESRI	Environmental Systems Research Institute
E1	Tall strata Eucalypt forest
F	*F* ratio
FAO	Food and Agriculture Organisation
FI	Freight income
FIAT	Forest Industries Association of Tasmania
FM	Fire management
FMC	Forest Management Credit
GE	Gross expenditure
GIS	Geographic Information Systems
GMI	Gross mixed income

GOP	Gross operating profit
GOS	Gross operating surplus
GR	Gross revenue
GWV	Green weight value
HC	Harvest cost
HLC	Haulage cost
HPV	High productivity vehicle
ICOMOS	International Council on Monuments and Sites
IFC	International Finance Corporation
IPA	Indigenous Protected Area
IUCN	International Union for Conservation of Nature
LIST	Land Information System Tasmania
MARXAN	Marine and SPEXAN (Spatially Explicit Anealing)
MDLV	Mill door landed value
me	Annual pavement maintenance cost
MESA	Million equivalent standard axel loads
MMG	Minerals and Metals Group
MRT	Mineral Resources Tasmania
MS	Mean squares
MW	Mineral / wood resource
M+	Tall *Nothofagus cunninghamii* forest
N	Net sales

NAF	*Acacia melanoxylon* swamp forest TasVeg 2.0 vegetation community code
NAR	*Acacia melanoxylon* forest on rises TasVeg 2.0 vegetation community code
NHL	National Heritage List
NPV	Net Present Value
NPVn	New net present value
NRM	Natural Resource Management
NRS	National Reserve System
NWI	National Wilderness Inventory
O*i*	Output multiplier impact value
OMULT	Direct output multiplier
OP	Operating profit
OPTA	Tonnes per annum
ORV	Off Road Vehicle
P	Significance level for the *F* statistic
P	Profit
p.a.	per annum
PGIS	Participatory Geographic Information System
PPGIS	Public Participatory Geographic Information System
PV	Present value
PVN	Potential visitor nights
R	Royalty
RBA	Reserve Bank of Australia

RC	Road capital
REDD+	Reducing Emissions from Deforestation and Forest Degradation
RFA	Regional Forest Agreement
RL	Rail maintenance
RM	Road maintenance
RNE	Register of the National Estate
ROI	Return on investment
ROS	Recreation opportunity spectrum
R-Sq	Coefficient of determination
S	Standard error
SAW	Simple additive weighted
SC	Stumpage cost
SD	Sustainable development
SKM	Sinclair Knight Merz
SLO	Social licence to operate
SS	Sum of squares
TasVeg	Digital Vegetation Map of Tasmania
TC	Tourism / carbon resource
TFA	Tasmanian Forest Agreement
TFIG	Tasmanian Forest Intergovernmental Agreement
TNC	Tarkine National Coalition
TPWS	Tasmanian Parks and Wildlife Service

TV	Tourism visitation
TVS	Total visitors to Tasmania
TWWHA	Tasmanian Wilderness World Heritage Area
UNEP	United Nations Environment Program
UNESCO	United Nations Educational, Scientific and Cultural Oragnisation
UNFAO	United Nations Food and Agriculture Organisation
USGS	United States Geological Survey
VGI	Volunteered Geographic Information
VMSD	Volcanic-associated massive sulfide deposits
WCMC	World Conservation Monitoring Centre
WHA	World Heritage Area
WHL	World Heritage List
WOB	*Eucalyptus obliqua* forest with broad-leaf shrubs TasVeg 2.0 vegetation community code
WOL	*Eucalyptus obliqua* forest over *Leptospermum* TasVeg 2.0 vegetation community code
WO	*Eucalyptus obliqua* forest over *Leptospermum*, *Eucalyptus obliqua* forest over rainforest, *Eucalyptus obliqua* forest with broad-leaf shrubs and *Eucalyptus obliqua* wet forest (undifferentiated) TasVeg 2.0 vegetation community codes
WOR	*Eucalyptus obliqua* forest over rainforest TasVeg 2.0 vegetation community code
WOU	*Eucalyptus obliqua* wet forest (undifferentiated) TasVeg 2.0 vegetation community code
WRP	Wood resource polygons

WTACL	Western Tasmanian Aboriginal Cultural Landscape
WWF	World Wildlife Fund
4WD	Four-wheel drive vehicle

Chapter 1 Introduction

1.1 Background

1.1.1 Environmental conflicts and land use change

Environmental conflicts relating to differences in preferences for the future of natural resources (Doak et al. 2013; Ives & Kendal 2014) are increasing (Escobar 2006; Bob & Bronkhorst 2012; Goetschel & Pe´clard 2012). Environmental conflicts involve numerous interest, agency and conflict arenas (Opotow & Weiss 2000; Hellström 2001; Balint et al. 2011; Walter 2012; Buchanan 2013). Deep disagreement on values has become a key problem in land use decision-making, rather than any lack of scientific certainty, lack of public understanding or lack of public participation (Balint et al. 2011). The effective management of environmental conflicts remains an ideal whilst current approaches to conflict resolution continue to be ‘regional, sectorial and unsustainable despite the proliferation of international policies and treaties’ (Bob & Bronkhorst 2012, p. 22).

Cumulative land use change is implicated in negative impacts on the global environment (Carr & Zwick 2007; Lambin & Meyfroidt 2011). Natural ecosystems continue to be converted to agricultural use to meet the demands of expanding populations and local and global economies (Foley et al. 2005; Lambin & Meyfroidt 2011). The growing appetite of urban consumers for material goods has driven foreign investment and land conversion to supply distant markets (Dobbs et al 2012; Meyfroidt et al. 2013). Land use changes are influenced by these complex socio-economic processes and matters of public interest (Buitelaar 2007; Meyfroidt et al. 2013). Therefore, there is a need to address these concerns and the multiple aspects of environmental conflicts and land use change.

In this context, the potential to polarise debate is high and continues to grow, as mass media often frame environmental conflict as a moralistic and ideological war between two opposing parties (Kirkpatrick 1987; Schwarze 2006; McCluskey & Kim 2012; Feinberg & Willer 2013; Fisher et al. 2013; Voyer et al. 2013). Carlisle & Smith (2007) argue that general attitudes to environmental conflict range from an individualistic support for development to an egalitarian support for conservation. In Australia, those in the ‘production sector’ value material goods highly compared with those in the ‘service sector’ and those who have grown up affluent highly value a clean environment (Tranter 1996). Environmental conflict can thus be perceived as ideological, a battle between self-interested neoliberals and those who believe they represent the interests of the environment (Wade-

Benzoni et al. 2002; Bamberg & Möser 2007; Hayter & Barnes 2012; West 2013). Such conflict is popularised as the 'growthists' versus the 'greenies' (Kirkpatrick 1988; Poritt 2011). 'Growthists' believe that the global economy can expand indefinitely (Douglas 2007), whilst 'greenies' advocate conservation (Whitehouse 2014). This dualistic framing of environmental conflict may sell newspapers, but may not reflect the reality, given that land use conflicts may occur between different types of recreationalists, such as off-road vehicle enthusiasts and bushwalkers, different forms of development, such as forestry and agriculture, and different cultures, such as Indigenous and Western. In any region, conflicts over land use are likely to be multidimensional rather than dualistic.

1.1.2 Environmental conflict in the Tarkine

In the island State of Tasmania, Australia environmental disputes are embedded in local culture (Flanagan & Pybus1990; 2003; Beresford 2010; West 2013) and have been constant since the 1960s (Kirkpatrick 1988; Buckman 2008; Willadsen 2009; Affolderbach 2011; Koshin 2011). The future of wilderness and forest is in dispute (Tranter 2009; Koshin 2011). In the twenty-first century, environmental conflict in Tasmania involves forest management (Dickenson & Cannon 2004; Montgomery 2004; Hollander 2006; Hickey 2009; Darby 2014), world heritage area extensions (Mosely 2013; Australian Broadcasting Corporation (ABC) 2015), paper pulp mill development (Gale 2009; Beresford 2010) and anti-protest and defamation laws (ABC 2014; Abey 2015, Safi 2015; Smith 2015b). Private businesses, unionists, conservationists, artists, governments and ordinary people are involved, with activists, business, politicians and mass media competing to control the conflict agenda (Lester & Hutchins 2009; 2012). To date there have been attempts resolve environmental conflict in Tasmania through the Regional Forest Agreement (Kirkpatrick 1998; McDonald 1999) and the Tasmanian Forest Agreement (Tasmanian Government 2011; Macintosh & Denniss 2012) with limited success (Darby 2014).

One of the longest running environmental conflicts in Australia relates to the future land use and management in an area labelled the Tarkine in northwest Tasmania (Figure 1.1 and Figure 1.7). This area has Australia's largest area of cool temperate rainforest, callidendrous rainforest on basalt soil, rainforest river landscapes and wet button grass moorland on granite country. It has Aboriginal cultural heritage and landscape values, coastal rock platforms, threatened Dasyurid species habitat, wilderness and aesthetic values. The area is used by a wide range of recreationalists, the activities of some of whom are incompatible. The Tarkine also has the potential for more extensive mineral extraction, forestry, tourism development and carbon trading.

The Tarkine is a contested place, with no agreement on definition, boundaries and values. Conflict in the Tarkine is multifaceted; it involves disagreements over land use, land access, tourism, recreational activities and management, is ongoing and not resolved.

Conflict over conservation values in the Tarkine focuses on extent, quality and status of wilderness, habitat and heritage values. This is expressed through arguments surrounding listing processes and heritage status at community and governmental levels. Land use conflicts involve logging of old growth and high conservation value forests, mining in wilderness reserves, cattle grazing on fragile coastal ecosystems and recreational impacts on Aboriginal cultural heritage. Land access conflicts take place on the coast between groups of recreationists, such as off road vehicle users and bushwalkers. Human activity in the Tarkine can reduce nature conservation values. These activities include inappropriate burning regimes, construction of roads, introduction of weeds and pathogens, logging and mining, mechanised recreation and cattle grazing (McDonald & McCaffrey 2011). On the coast 'graves in which shell necklaces have encircled resting bones since before Christian time' are trampled by cattle hooves permitted by State sanctioned agistment (Lehman 2013, p. 205).

Spatial and conceptual conflicts between natural and cultural values in the Tarkine persist. The Tarkine (447,606 ha) was nominated for the National Heritage List in 2004 by the Tarkine National Coalition as 'one of the world's great wild places with remarkable natural and cultural values' (Tarkine National Coalition 2012). In 2013, a small portion of the nominated area of the Tarkine (Western Tasmanian Aboriginal Cultural Landscape, 21,000 ha) was added to the National Heritage List despite 447,000 ha being recommended by the Australian Heritage Council (AHC) (Darby 2013). The Cradle Coast Authority and the Circular Head Council criticise the AHC assessment (Ford 2011). Environmental groups lobby for World Heritage listing (The Wilderness Society 2015; Save the Tarkine 2016).

At a Local Government level the Tarkine is described as an 'asset for recreation, a place to hunt, fish, ride, drive, camp, fossick and walk', a place where European recreational use is described as tradition and a 'means of accessing country, a way of maintaining cultural links to the land' (Quilliam 2008, p. 4). The area is considered as 'the last place in Tasmania where people can recreate free of controls and restrictions' (Good 1991, p.23) expressed by as low as 50 percent compliance with off road recreation vehicle (ORV) permit systems (Tasmanian Parks and Wildlife Service 2007). ORV users state that middens 'were not created by Aboriginal activity' thus allowing people to 'quite comfortably ride over them' (Good 1991, p.52). Petroglyphs at Greenes Creek and Sundown Point have been vandalised (Bednarik 2006; Sims 2013) whilst Tasmanian Aboriginal organisations continue to raise concerns in relation to lack of protection of Aboriginal cultural heritage at key sites, including the Arthur-Pieman Conservation Area (APCA) (Cradle Coast NRM 2010). Mackay (2011, p. 2) calls for cooperation by 'developing an understanding of differing viewpoints and breaking down the legacy of distrust' in order to gain future cooperation on reserve management in the APCA, whilst others describe the ORV destruction of Aboriginal cultural heritage as 'systematic trashing… deliberate vandalism, the epitome of management ineptitude' (Hay 2011, p. 2) and 'continuation of genocide' (Coles, 2013, pers. comm., 18 September).

A study of the social values of the APCA found that the Tarkine coast is a place of deep and multi-layered meaning for the Circular Head and North West Tasmanian community who use the area (Mackay 2011). There is 'a sharing of high level social values across the spectrum of interests and users', although views on the appropriate management of the area differ (Mackay 2011, p. 1). These high level values relate to the Tarkine coast as a place that is wild and remote, increases social and family bonding, helps pass on traditions and values, provides opportunities for adventure, relaxation and rejuvenation and has spiritual values (Mackay 2011). These results are consistent with the results of ethnographic research on Tasmanian West Coast communities (Knowels 1997). Economic values and a sense of stewardship were also listed as high-level social values (Mackay 2011). Associated with this strong attachment to place is a reluctance to adopt responsible off road vehicle use, protect natural and cultural values and manage the landscape sustainably (Mackay 2011). A culture of distrust of external management has developed amongst the local people, with the key fear of being 'locked out' and constrained by potential changes to the areas' reserve status (Mackay 2011).

Tasmanian environmental disputes involve complex geographies (West 2013), which are rooted in cultural and historical contexts (Cubit 2001), are place based and may involve moral ecologies (Hay 2008). On the ground protests peaked in 1995 during the 'Tarkine Road to Nowhere Blockade' (Gee 2001; Tranter 2009). The 'Tarkine Tigers' conservationists were joined by health union workers to try to prevent the construction of the Western Explorer Road (Gaiswinkler 1995; Shearman & Sauer-Thompson 1998; Lines 2006; Tranter 2009). A government-imposed media void and lack of lobbying activity by the conservationists allowed polarised views of 'greenies' versus developers to persist, and the Government to maintain control of the conflict (Courtice 1995). Polarised views on the future of the Tarkine have endured. They are reflected in current social media (Pro Development Coalition 2015; Save the Tarkine 2015; Unlock Tasmania 2015; We Love Tasmania 2015).

Since 1995, there has been disagreement on National Heritage listing, four wheel drive access, mining, devil disease impacts, damage to Aboriginal heritage and impacts of conflict on tourism (Cullen 2011; Darby 2012a; Denholm 2012; Pippos 2012). Conflict over new mines and four-wheel drive access on the coast has been prominent in the media. The largest conflict event after 1995 was the ‘Save Our Heritage’ rally in Smithton in 2012, relating to ORV access on the Tarkine coast (Pippos 2012; Yard 2012), where public speakers and members of the audience expressed personal dislike of individuals and organisations as well as calling for illegal behaviours. During 2012, there were five action groups holding polarised views and positions in relations to the future of the Tarkine: *Save the Tarkine, Save the Tarkine Melbourne Action Collective, Pro Tarkine Development Coalition, Stop the Arthur-Pieman Conservation Area Track Closures* and *Save Our Heritage*. These groups were active on social media and represented 7,143 members (Facebook 2012a; 2012b; 2012c; 2012d; Save Our Heritage 2012).

In October 2012, conflict intensified when State Opposition politicians joined forces with mining interests and Local Councils against all environmental groups and their threats to mount a Franklin Dam styled blockade against new mining projects (The Advocate 2012). Conflict escalated from media debate to interpersonal conflict (Ford 2013; Sims, 2015, pers. comm., 18 September; Wilson, 2015, pers. comm., 18 September; Johnson, 2014, pers. comm., 13 March). The most recent on-ground protest was a peaceful vigil in April 2013 by conservationists against the development of the Shree Minerals mine (Kempton 2013). Despite the lack of recent on-ground protest activity, conflict is unresolved and likely to escalate (McDonald 2013). The conflict narrative of the Tarkine demonstrates the complexity of resolving disagreement over multiple expectations and use of land and ecosystem resources.

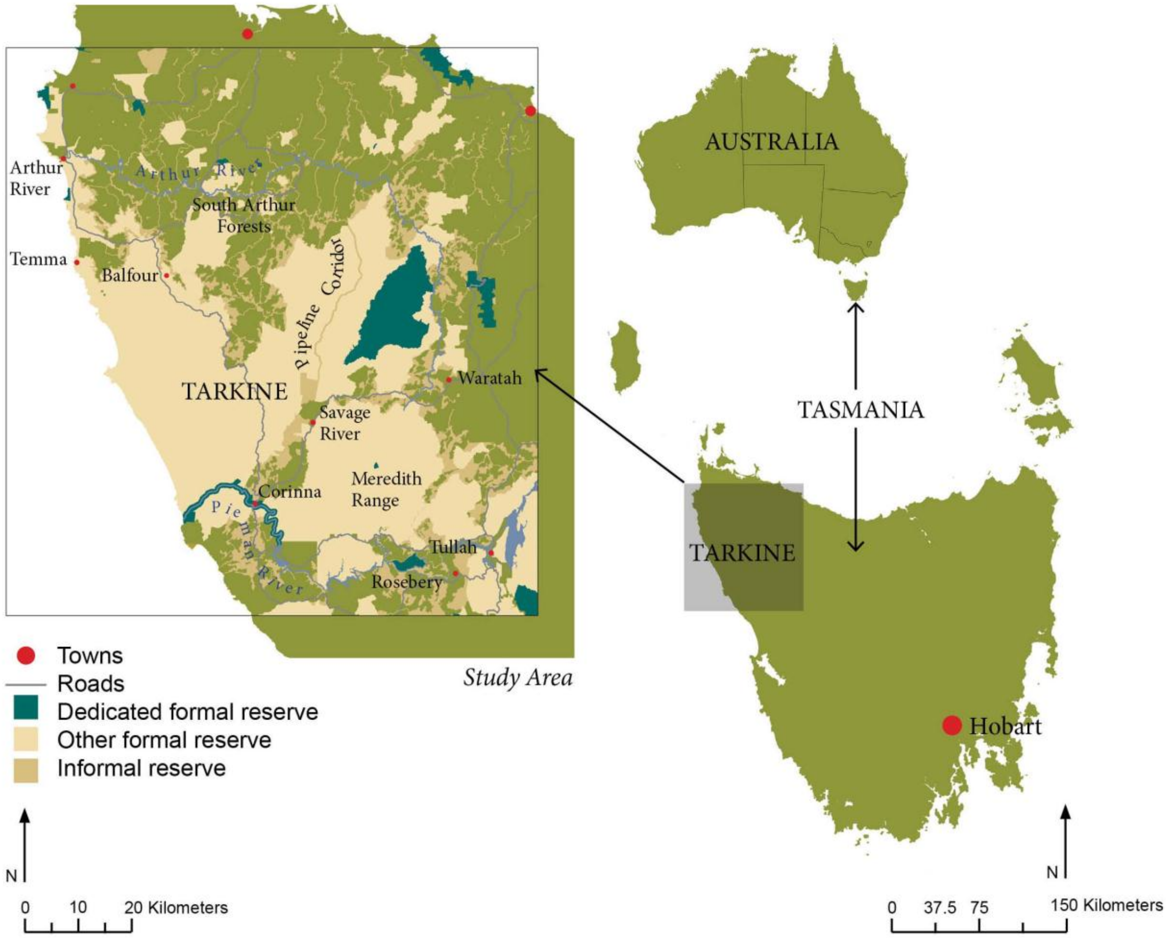

Figure 1.1 – Study location, the Tarkine

1.1.3 Current approaches to resolving land use conflict

Systematic approaches for dealing with conservation conflicts are thought to require much further development (Young et al. 2016). Approaches to the resolution of conflict differ in the amount and type of participation and deliberation, and the extent and nature of scientific analysis that informs deliberations (Rauschmayer & Wittmer 2006). Participation processes and scientific analysis are not always used together (Rauschmayer & Wittmer 2006). Furthermore, the local conditions and the interactions between environmental, social and economic factors are often overlooked (Hersperger et al. 2015).

Multi-stage engagement processes have been developed to identify and manage conflicts (Young et al. 2016). Most work focuses on conflict resolution processes rather than identifying the characteristics of the conflict, although these characteristics have been defined in some urban and peri-urban contexts (Hersperger et al. 2015). Whilst conflict mapping has been widely used (Brody et al. 2006; Carr & Zwick 2007; Brown & Raymond 2014), accurate identification of potential conflict and the potential for trade-offs is generally lacking (Hersperger et al. 2015).

Therefore, designing an appropriate combination of deliberative and scientific components to systematically address specific land use disputes is challenging. Some have recommended that improvements can be made to land use conflict resolution by anticipating conflict and integrating it into planning processes (Hersperger et al. 2015). Others have suggested that participatory and multi-criteria methods could be combined to resolve environmental conflict (Rauschmayer & Wittmer 2006). The development of ways in which to improve the use of analytical tools in deliberation is advocated (Rauschmayer & Wittmer 2006). Future research on the direct mapping of economic values to improve trade-offs options and conflict distribution has also been recommended (Brown and Raymond 2014).

Public participatory GIS (PPGIS), participatory GIS (PGIS) and volunteered geographic information (VGI) processes, all forms of conflict mapping, have been used successfully in developing and developed nations (Brown & Kyttä 2014). The techniques have been used since the 1980s to expose value differences between entrenched foes (Piccolella 2013) and to assist in the resolution of conservation-development conflicts (Redpath et al 2013). Methods and approaches are experimental, only limited by the creativity of the researcher (Watts 2010).

At the operational level, the process of mapping conflict with GIS software uses either raster or vector methods. The spatial analysis phase using GIS almost exclusively involves assigning values to a single grid cell or point (Brody et al. 2004; Kwaku Kyem 2004; Brown 2005; Brown 2006; Brown and Raymond 2006; Nielsen-Pincus et al. 2010; Bryan et al. 2011; Nielsen-Pincus 2011; Raymond & Curtis 2013; Brown & Raymond 2014; Whitehead et al. 2014). This raster approach is restrained by pixel size. Although GIS software has the capacity to create polygons, in a vector approach, the raster approach dominates the literature (Bader and Weibel 1997; Brown 2005; Raymond et al. 2009). Some suggest that a vector approach might be beneficial in face-to-face PGIS (Brown & Pullar 2012) as it may be able to enhance participation and knowledge-sharing (Brown 2005).

An integration of research into attitudes and values with PGIS processes can provide new insights into spatial and non-spatial factors that influence preferences (Balram & Dragićević 2005). Whilst attitudes and preferences have been used to inform and create GIS maps / data layers, research that uses reciprocal triangulation between attitudinal syndromes, and PGIS participant spatial preferences is absent. This thesis aims to address this research gap by systematically integrating and reciprocally triangulating attitudes and preferences with PGIS processes.

1.1.4 Addressing the research gap using the Tarkine as a case study

The Tarkine is a complex place, characterised by entrenched conflict. It provides ideal attributes suitable for a case study for identifying potential conflict compromise and levels of agreement for land use. Suggested solutions for land use conflict in the Tarkine to date include a regional sectoral management plan (McDonald 2013), the implementation of participatory and deliberative governance practices (Campbell-Ellis 2009) and the establishment of independent heritage assessment processes (Macintosh & Wilkinson 2012).

Spatial research on the Tarkine has included natural value surveys (Macphail et al. 1975; Harries 1995; Tasmanian Parks and Wildlife Service 2007; Australian Government 2011a & 2013a; Evans 2011e), cultural heritage studies (Stockton 1982; MacFarlane 1992; Collett et al. 1998; Cosgrove 1990; Pedder, Hughes & Edwards 2007; Haygarth & Cubit 2008; Huys 2010), investigations relating to Regional Forest Agreement (Australian Government 1997a), Tasmanian Forests Intergovernmental Agreement (Australian Government 2011b), National Heritage Listing processes (Australian Government 2011a; 2013a) and ecosystem services (Williams 2011). The spatial analysis has focussed on specific values relevant to reserve or listing boundaries, natural resource management and recreational impacts but has not been designed to identify and resolve conflict.

Cultural research on the Tarkine has focussed on community attachments to the coastal landscape. Traditional recreational activity and social values have been investigated (Good 1991; Mackay 2011) as has degradation of Aboriginal cultural heritage values in the landscape (Jones 2007). These studies used qualitative research methods to investigate specific coastal land use issues. Whilst they did not quantify attitudes associated with conflict, their findings described the cultural significance and impacts of traditional recreation.

There is a need to understand if acceptable land use resolution can be attained in the Tarkine and to determine the spatial implications for conservation and development from such resolution. One tool that has not been used in Tasmania is conflict mapping which is promoted as an effective tool in the process of resolution of conservation-development conflicts (Redpath et al 2013). Therefore there is a need for a thorough analysis to address all aspects of land use conflict in the Tarkine. The Tarkine is a complex region with contested high conservation values and potentially high economic values, both of which have resulted in persistent conflict between individuals and communities. A systematic approach that integrates the multifaceted values and valuing of the Tarkine is required to illuminate such complexity for land use decision makers. Given the diversity of conflict in the Tarkine, the application of a systematic land use resolution approach described above could be an exemplar on a global basis.

In summary, current research demonstrates a plethora of partial approaches to land use conflict resolution, but no systematic methods for combined participatory and scientific approaches. There is a gap in the current research for the exploration and design of systematic approaches to land use conflict resolution that: combine multiple methods, anticipate and define the characteristics of conflict, respond to local conditions and integrate attitudes, preferences and economic values. PGIS methods that use the vector approach and reciprocal triangulation between attitudinal syndromes, conflict mapping and participant spatial preferences address this gap. Reciprocal triangulation methods can elucidate multi realities and expose their incommensurability (Hammersley 2008) and may be useful in establishing the values that influence conflict. The application of reciprocal triangulation methods in conjunction with conflict mapping and PGIS therefore can assist in identifying the potential of conflict compromise. Using the Tarkine as a case study, this research develops an integrated methodology to resolving land use conflict.

1.2 Research aims and structure

The major aim of the thesis is to develop an integrated approach to resolving land use conflict. The Tarkine, being a complex and contested place, is used as a case study to test the approach. A sequence of research tasks is used to identify the potential conflict compromise in the Tarkine (Figure 1.2). There are five research tasks: 1) natural values identification, 2) values significance quantification, 3) optimal land use quantification, 4) values conflict identification and 5) potential conflict compromise identification. Each research task involves varying combinations of multiple methods to identify and quantify values. The results from each research task are used systematically to inform the proceeding research task.

The first research task is to identify natural values of the Tarkine, focussing on three values themes: *a.* natural assets (conservation significance), *b.* economic assets (economic land uses), and *c.* human agency (attitudes and preferences). This initial research stage involves data mining of spatial data, quantitative and qualitative data, analysis of the gaps in current knowledge and collection of new data to fill knowledge gaps. The scope of enquiry is aimed at determining both perceived and measured values and their spatial distribution for mapping. The second and third research task is to map the spatial variation of values. This involves several steps: defining the level of importance and significance of values being mapped, determining the method to commensurate the significance of values and to establish spatial patterns of land use where values are compatible and incompatible and land use trade-offs.

From these tasks the nature and distribution of conflict is determined. This is achieved by reciprocal triangulation of spatial and non-spatial analysis using data on attitudes and preferences collected through PGIS processes. The patterns for areas that are contested, uncontested and open to potential compromise are mapped. The final research task is to determine if there is willingness to compromise potential outcomes between competing value interests and research participants. This task involves reciprocal triangulation of stakeholder attitudes and preferences, significance quantification of conservation and economic values and levels of agreement for land use.

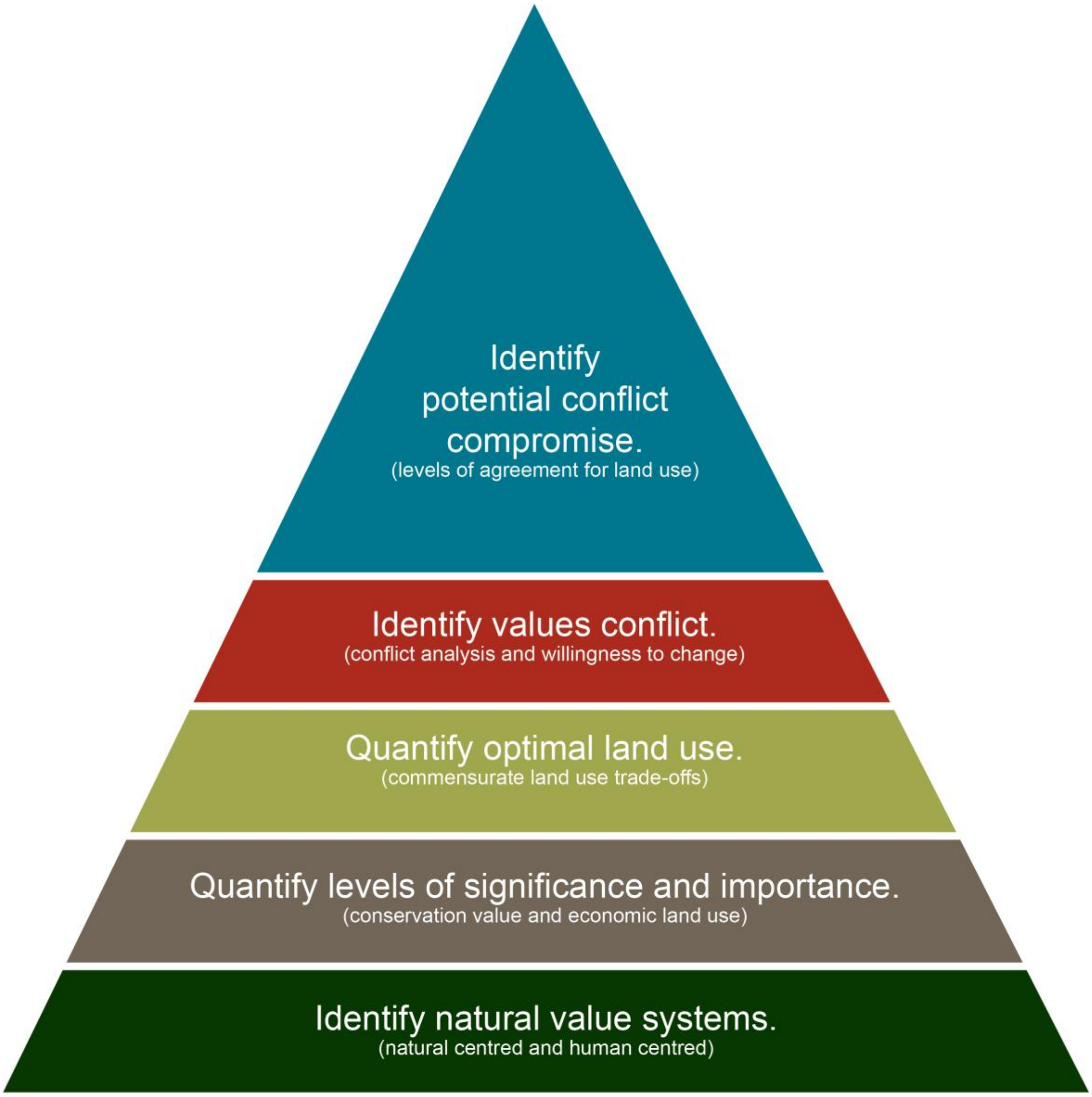

Figure 1.2 – Systematic land use resolution approach.

1.3 Conceptual context

The first research task involves the identification of the natural value systems that are in contestation. There are two main foci for conflicting value systems: 1) natural centred context (values created by people focussing on nature) and 2) human centred context (values created by people focussing on human benefits attained from nature). The natural values of the Tarkine are quantified through a series of independent metrics that express the conflicting value systems inherent between natural and human centred value systems (Figure 1.3). Each set of metrics creates base data for values mapping and conflict analysis.

Distinct natural value elements such as rainforest, biodiversity, wilderness, cultural landscapes and aesthetics are then tested for conservation significance within a nature-centred context. Human-centred values such as natural resource extraction, people attachment and human services derived from ecosystem services are also quantified.

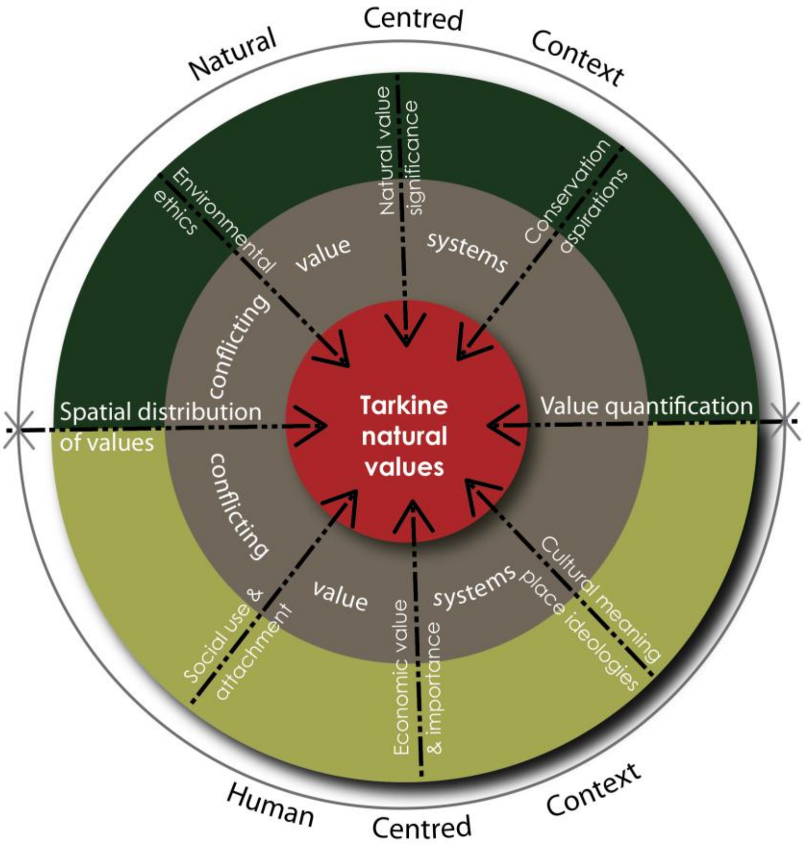

Figure 1.3 – Identification of natural value systems.

The second research task involves the assessment of natural and human centred values to determine their spatial distribution and levels significance based on quantifiable data. The resulting natural value assessment describes the base natural value and the human value placed upon it. Natural values are also assessed against hierarchical political and institutional frameworks. These include values that are categorised as biotic, abiotic, cultural and planning and management by Smith & Theberge (1986) and have *held* principle characteristics (Lockwood 2005). Examples of these natural values are biodiversity, geology and natural landscapes. Human-centred values are assessed against abstract frameworks with conflicting values of importance. These include values that are categorised by Smith & Theberge (1986) as cultural and planning and management. This value set has no hierarchy as a group, but is hierarchical within each value (Figure 1.4). It involves *assigned* values (Lockwood 2005; Trainor 2006; Seymour et. al 2010). Examples of these natural values are wilderness, aesthetics and cultural landscapes.

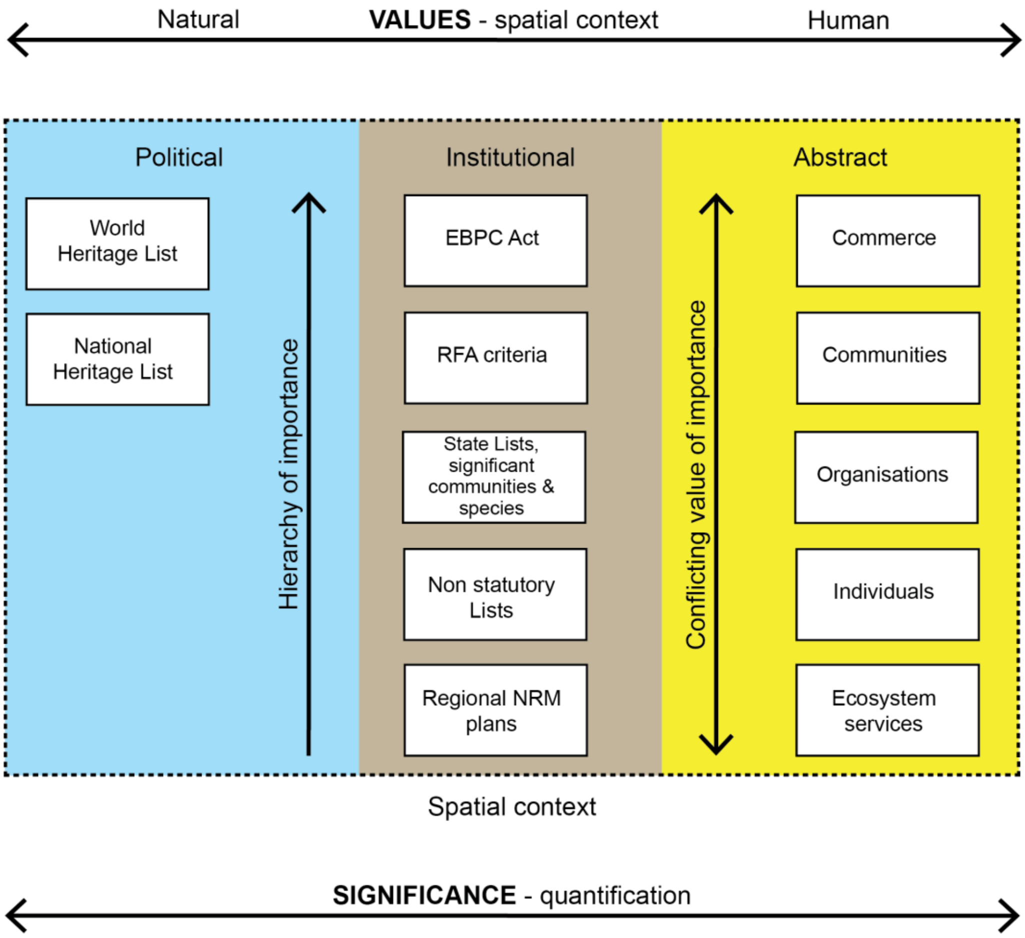

Figure 1.4 – Quantifying levels of significance.

1.4 Methodological context

Triangulation methods are used to integrate quantitative and qualitative data (Bryman 2006) and to test validity and reliability of iterative analyses (Given 2008). Methods involve the triangulation of multiple data types, triangulation of data from different data sources, using different methods or by integrating different methodological approaches (Hammersley 2008; Denzin 2009). Whilst popular, triangulation methods have been criticised as eclectic (Fielding & Fielding 1986), technic (Hammersley 2008) and inaccurately portraying ‘objective’ truth (Flick 2004). Triangulation methods have been used to deepen the understanding of phenomena in human geography (Hay 2005; Bradshaw & Stratford 2005; Eden, Donaldson & Walker 2005), ethnography (Fetterman 2010), sociology (Olsen 2004; Denzin 2009; Hussien 2009), psychology (Hanson et al. 2005; Leech & Onwuegbuzie 2007; Frels & Onwuegbuzie 2013) and conflict resolution (Winn & Keller 2001; Longaretti & Wilson 2006; Smolander & Rossi 2008). Systematic triangulation methods that purposefully and rigorously combine the triangulation of methods and data with the triangulation of theoretical perspectives can address methodological deficiencies (Flick 2004; Bradshaw & Stratford 2005).

Reciprocal triangulation involves the application of different methods to the same object to understand multiple viewpoints and contexts (Flick 2004; Hammersley 2008). The thesis uses reciprocal triangulation methods to illuminate potential land use conflict compromise in the Tarkine (Figure 1.5). Multiple methods are used to determine a) the significance of natural values, b) preferences and attitudes and c) levels of agreement for land use. The results from each of these are then reciprocally triangulated to determine the potential for land use conflict compromise (Table 1-1).

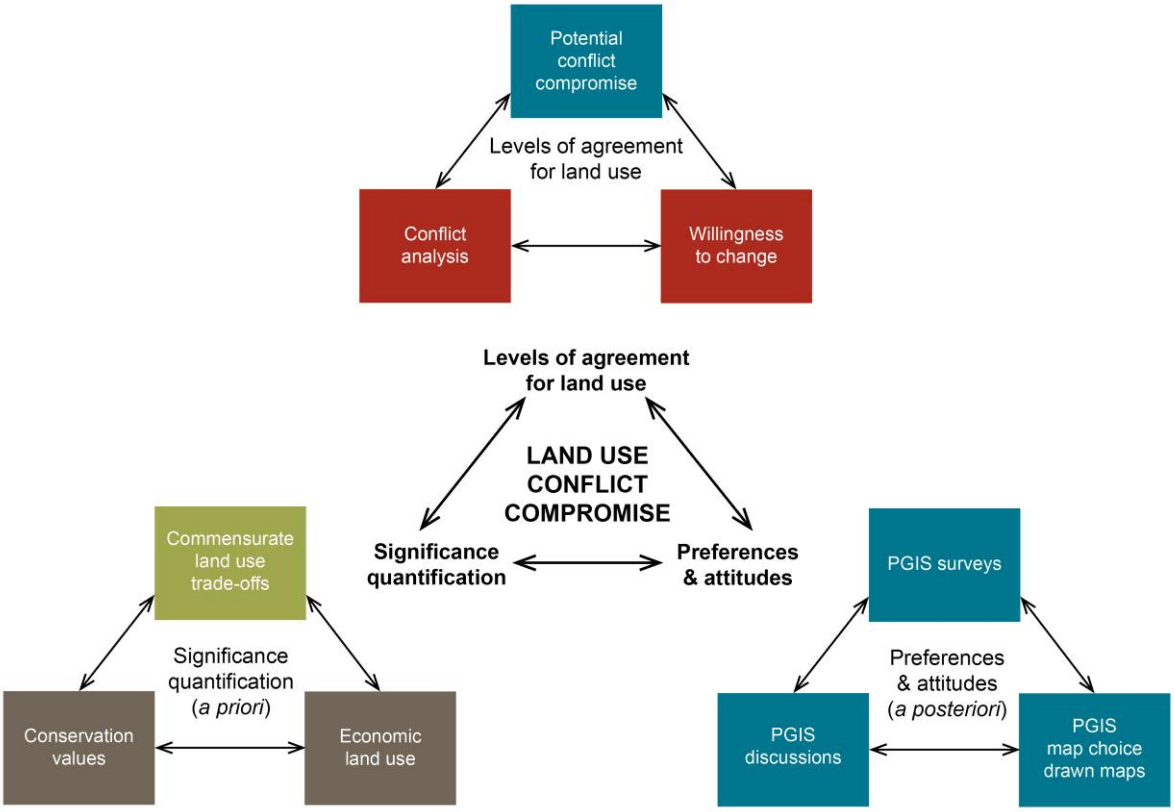

Figure 1.5 – Reciprocal triangulation architecture.

Table 1-1 – Data analysis methods summary

Research objective	**Data inputs**	**Data analysis**
Identify potential conflict compromise.	Spatial and non-spatial results from conflict analysis, optimal land use, conservation and economic value significance and importance.	Reciprocal triangulation of: stakeholder attitudes and preferences, significance quantification of conservation and economic values, levels of agreement for land use, and PGIS database.
Identify values conflict.	Mapped *a priori* and *a posteriori* contested areas and PGIS workshop data integrated into PGIS database.	Reciprocal triangulation of: individual and group preferences (non-spatial), willingness to change model and preferences integrated into PGIS database. Conflict mapping.
Quantify optimal land use.	Mapped *a priori* conservation and economic values with significance levels applied.	Commensuration of significance values and GIS scoring system for land use trade-offs.
Quantify levels of significance and importance.	Mapped conservation and economic value GIS layers and existing research.	Simple additive weighted, Boolean, proximity, weighted concentration, presence and sum mapping methods in GIS. Legal recognition, relative distribution, rarity and distinctiveness. Cost-benefit analysis and net present valuation.
Identify natural value systems.	Conservation, economic and attitudinal values identified by others.	Relevance, integrity, quality, scale and suitability for mapping.

1.5 Structure of thesis

In response to the research tasks, the thesis is structured around three substantive chapters: i) the heritage importance of conservation values, ii) the pattern of optimal economic use and iii) identifying conflict in the Tarkine using group attitudes, value preferences and conflict scenarios (Figure 1.6). Chapters two and three involve the mapping of conservation and economic values, verifying their significance and developing objective and biased land use trade-off maps. Chapter four systematically integrates the results from the preceding chapters with PGIS data to determine the scope for land use conflict compromise using reciprocal triangulation methods.

Chapter two quantifies the heritage importance of conservation values in the Tarkine. Conservation values that may meet World Heritage criteria are discussed in this chapter.Chapter three determines potential patterns of economic land use in the Tarkine by calculating the spatial patterns of net present value for alternative uses. Variable discount rates, time frames and output multipliers are used in this process.

Chapter four discusses the subjective valuing and trade-offs between conservation and development desires of the research participants (Figure 1.6). The hypothesis that: conflict is multidimensional; that informed discussion of values leads to increased willingness to compromise potential outcomes; and, that variation in such willingness is predictable is tested. This chapter uses a novel reciprocal triangulation of data on attitudes and PGIS to identify the nature and distribution of conflict in the Tarkine.

Spatial sensitivity analyses are conducted to test the robustness of the findings from chapter three (economic values) and chapter four (attitude and value preferences). These analyses determine the extent of potential spatial variations a) between the *a priori* and *a posteriori* significance quantification of the natural values and b) between the multiplier and non-multiplier effect on economic land use.

Chapter five provides a general discussion of the importance and meaning of the substantive chapters, thesis conclusions and future research. It reviews the research findings and their contribution to scholarly work and suggests a way forward to resolve conflict in the Tarkine. This chapter has an atypical component, in the form of a practical example of how the research may be applied in a second iteration to quantify future trade-offs and advance conflict resolution processes. The working example aims to demonstrate the inherent flexibility of the database and the general conflict resolution approach developed in this thesis.

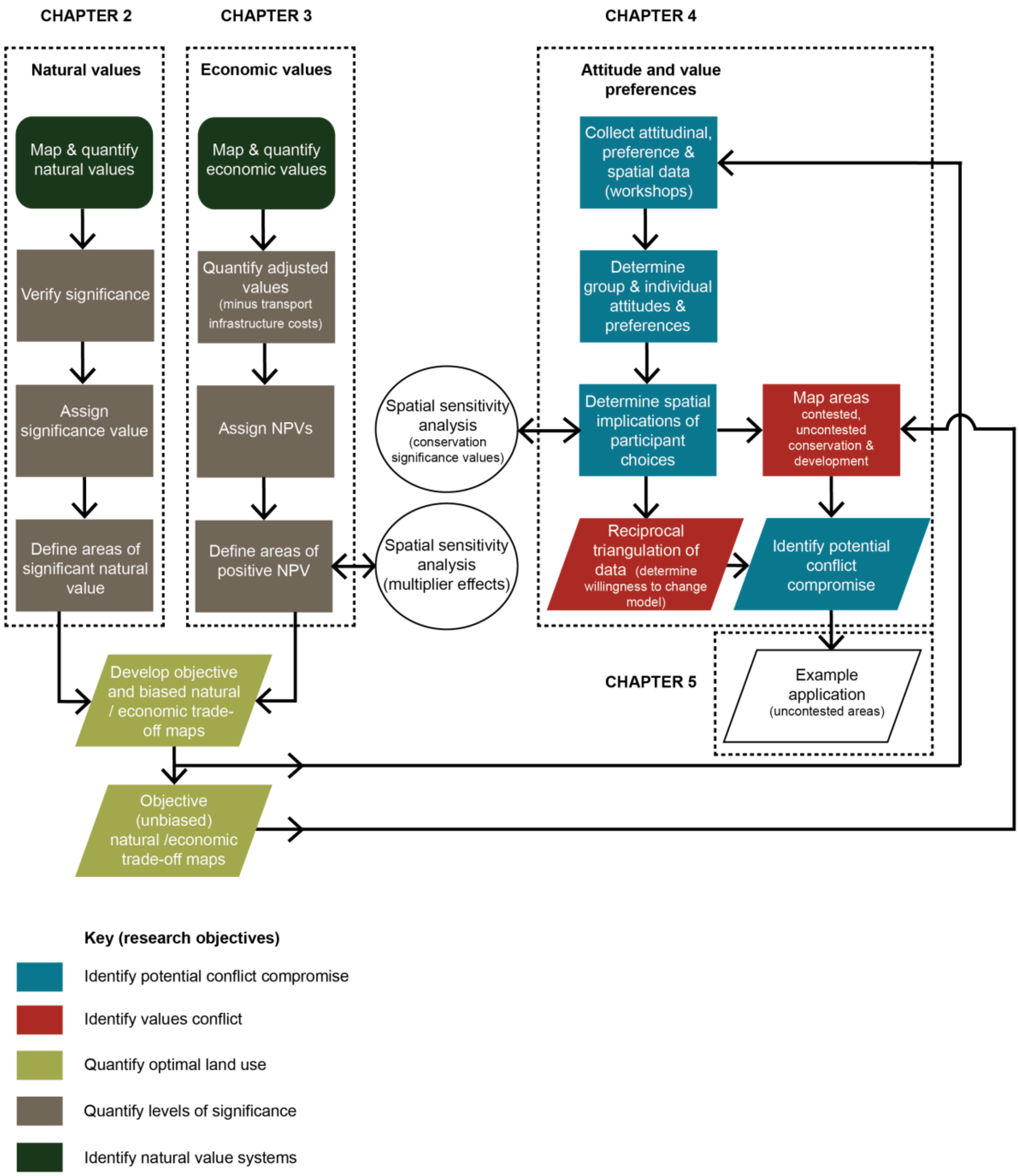

Figure 1.6 – Thesis structure and the three substantive chapters.

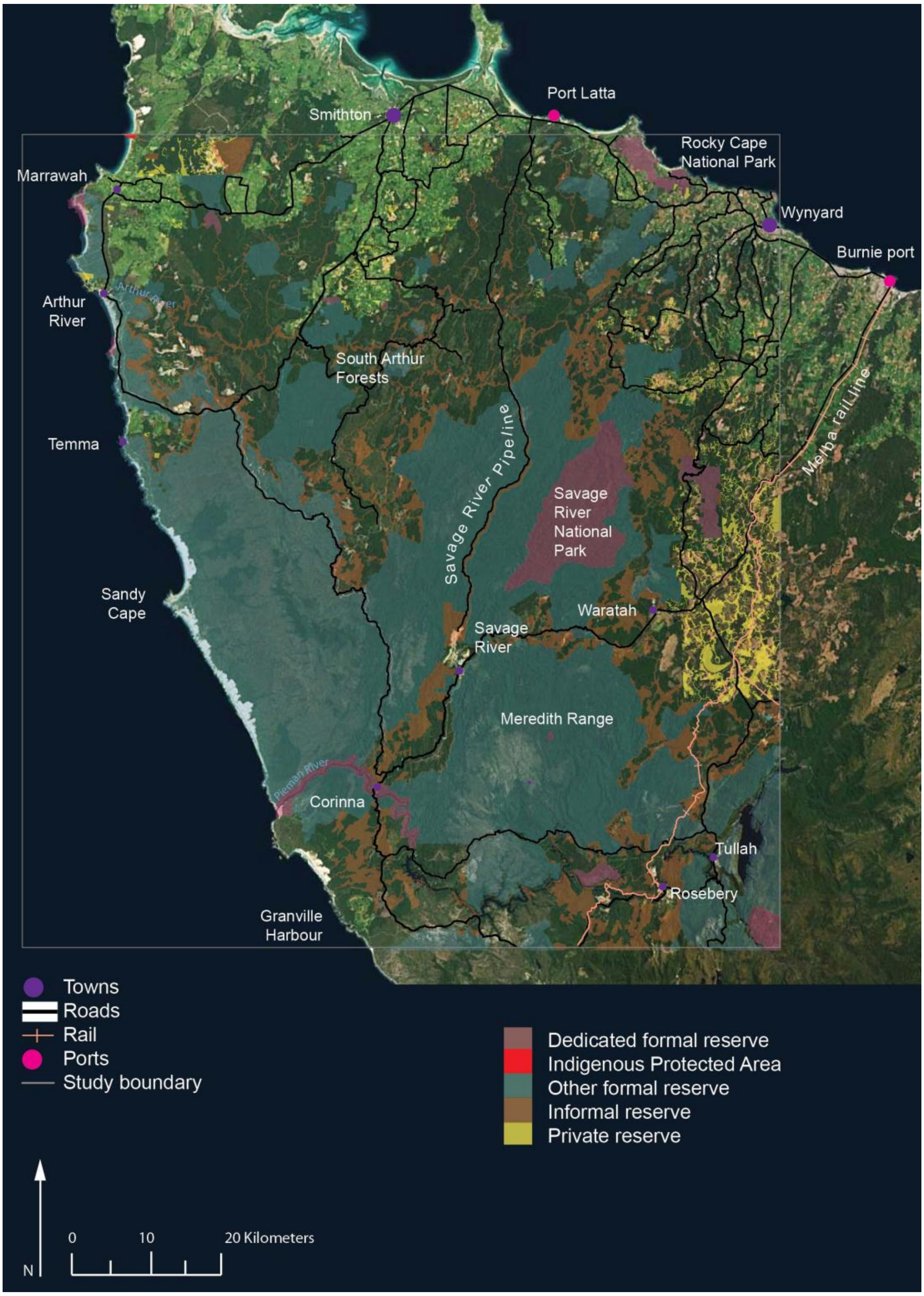

Figure 1.7 – Study site, the Tarkine.

Chapter 2 Assessing the heritage importance of conservation values in the Tarkine

2.1 Chapter overview

This chapter assesses the heritage importance of conservation values in the Tarkine. It establishes that conflict resolution can be aided by understanding the significance of conservation values. It reviews the various existing methods for assigning significance value and the existing research for quantifying conservation values in the Tarkine. The methods section describes the approach used to determine levels of significance and importance and explains the GIS scoring system that reflects the significance levels of conservation values. The results report the nature and distribution of conservation values extant in the Tarkine and their significance levels (i.e. international, national, State and regional). The discussion section of the chapter looks at World Heritage significance, the contestation of wilderness values, issues relating to the use of simple additive weighted (SAW) methods and the significance of the Aboriginal cultural landscape values.

The term conservation value in this thesis refers to natural features in the landscape (biotic and abiotic) that are valued for their significance using political and institutional frameworks, comparative distribution, rarity and distinctiveness. The term economic value in this thesis refers to conservation values that have consumptive value to humans (e.g. minerals and forests). These conservation values are valued for their economic return to the region after factoring transport infrastructure life cycle costs incurred to support their development. The final valuing of conservation values in this thesis considers the personal benefit that conservation values provide to people.

2.2 Introduction

Resolution of conflict between development and conservation may be helped by an understanding of the relative value of different parts of contested landscapes for conservation of natural values (Davies, Bryce & Redpath 2013; Dudley et al. 2014; Stolton et al. 2015). This process requires quantification of spatial variation in the value of particular aspects of nature, and commensuration between the values derived for these aspects (Brown & Reed 2012; Freeman, Herriges & Kling 2014). In the present work, conservation value is defined as the perceived worth of elements or processes of nature if they are maintained in their current dynamic state.

Expressed attitudes and preferences in relation to natural values can be difficult to measure (Hettinger 2008; Choy, Wadsworth & Burns 2011). The products of such measurement have been criticised as subjective and illusory (Cronon 1995; Nash 2001; Flannery, cited in Washington 2006; Hettinger 2008; Brown, Raymind & Corcoran 2015). Attitudes and preferences can be strongly culturally contingent. For example, Indigenous people value landscapes through aesthetic patterns of land stewardship with integral and complex cultural connections through space and time (e.g. ‘connection to country’ and ‘songlines’). These are invisible to non-Indigenous people (Lewis 2005, 2008; Taçon 2010; Clarke 2015) some who see the aesthetics of landscape as relating to relative relief and the presence of water (Mendel and Kirkpatrick 1999) and perceive valuable wilderness (Naess & Sessions 1984; Carver, Tricker & Landres 2013) where as Indigenes perceive an integration of people with the rest of nature (Rose 1996; Langton 2000).

Existing methods for measuring aesthetics, wilderness and place attachment are rooted in Western paradigms (Pocock 2002; Kingsley et al. 2013; Kingsley, Townsend & Henderson-wilson 2013). Aesthetics are valued using two broad approaches: 1) definition of aesthetically distinct environments and 2) subjective community perceptions of the landscape (Wu et al. 2006). Both approaches are predicated on the assumption that certain attributes of the landscape are beautiful, which is ultimately a product of cultural, social and psychological orientation (Lothian 1999). Wilderness areas can be defined by the perceptions of respondents (Vaughn 2011) or by biophysical attributes of naturalness and primitiveness based on assumed recreational preferences (Kirkpatrick 1979; Cordell, Bergstrom & Bowker 2005; Carver, Tricker & Landres 2013). The measurement of place attachment focuses on determining the strength of emotional bonds or repulsions (Lewicka 2011). Measurement of Indigenous place attachment may focus on ecological, natural and aesthetic values (Stephenson 2008), but these values are subservient to embedded spiritual values such as ‘connection to country’ (Choy, Wadsworth & Burns 2011; Lee 2015) which are difficult to transpose using Western Cartesian methods (Brazenor, Ogleby & Williamson 1999; McGaw 2014).

Despite its apparent concreteness in the context of attribution of virtue to its maintenance, the measurement of the conservation value of biodiversity is highly contested (Pielou 1977; Lovejoy 1997; Swingland 2001; Magurran 2004). Because biodiversity maintenance requires that a large number of entities be maintained, a simple additive approach can lead to spatial values that do not reflect conservation significance (Kirkpatrick 1983). A wide variety of methods has been devised to overcome this problem, including the original iterative approach (Kirkpatrick 1983), pure optimisation (Kirkpatrick et al. 2015), approaches to optimisation, such as the program MARXAN (Cocks & Baird 1989; Ball, Possingham &Watts 2009), and the use of irreplaceability scores (Pressey et al. 1993; Pressey, Johnson & Wilson 1994). These methods are applied using targets derived from basic conservation principles and provide either a ranking or a score.

It is possible to quantify all conservation values in themselves; the problem lies in relating these scales. One way of relating is to rely on the judgements of a set of individual people on the importance of particular areas for particular natural values. Some such judgements have been codified in pre-existing legal classifications of significance (e.g. world heritage, national heritage and reserve classes). At the highest level, the World Heritage List (United Nations Educational, Scientific and Cultural Oragnisation (UNESCO) 2015) recognises the 'outstanding universal value' of sites that are large enough to sustain integrity.

In Australia, the Natural Heritage List recognises places that are outstanding in natural, Indigenous or historic value (Australian Government 2015b). The comprehensive, adequate and representative reserve system (CARRS) has been recognised as the global comparative system for protected areas (McIntyre-Tamwoy 2004) and is operationalised in Australia through the National Reserve System (NRS). Although the legal status of a natural area demonstrates a level of significance of conservation values, it is often more the result of political decision making processes than logical procedures (Macintosh & Wilkinson 2012).

Significance of natural values can exist without formal recognition. Inscription in lists and conventions must logically follow prior informal recognition (Kirkpatrick 1994; Balmer et al. 2004). Measurement and commensuration of conservation values are therefore vital in establishing the relative significance of places. The distinctive biophysical characteristics of the locale in question can be identified and relevant characteristics mapped. The levels of significance can be determined following a rule set. A site that contains a distinctive set of biophysical characteristics that has limited geographic distribution (i.e. is one of, or a few, or the best example globally) can be considered representative of a rare environment (Mackey et al. 1989) and internationally significant (Brocx & Semeniuk 2011). Comparisons can be made between the study site and others of similar biophysical characteristics with pre-existing formal significance at the international significance scale using weighted criteria for relative performance on world heritage criteria (Kirkpatrick 1994; Lothian 2014). A site that contains a distinctive set of biophysical characteristics but is relatively common globally however is one of, or a few, or the best example nationally, can be considered nationally significant (Brox & Semeniuk 2011). Comparisons can be made between the study site and others of similar biophysical characteristics with pre-existing formal significance at the national significance scale using thresholds for National Heritage criteria (Australian Government 2013c). A site that contains a set of biophysical characteristics that are relatively common globally, but is which is one of the best examples of these characteristics at the subnational (State) level, can be considered subnationally significant (Brocx & Semeniuk 2011).

Previous research on the Tarkine study area suggests a broad range of natural conservation values: rainforest, rainforest river landscapes, old growth forest, tall eucalypt forest, native vegetation, lichen, fungi, biodiversity, threatened flora and fauna, soils, geology, geomorphology, geoconservation, magnesite karst, rainfall, wilderness, aesthetics, coastal interdigitation, natural landscapes, designated conservation areas, carbon, social values (Harries 1995; Australian Conservation Foundation, Environment Tasmania & The Wilderness Society 2011; Evans 2011e; Williams 2011; Australian Government 2011a & 2013a). It has also been valued for its archaeological resources (Stockton 1982; Cosgrove 1990; MacFarlane 1992; Harries 1995; Collett et al. 1998; Pedder, Hughes & Edwards 2007; Huys 2010; Evans 2011e; Australian Government 2011a & 2013a; Sims 2013). Hotspots of natural values have been identified (Harries 1995; Australian Conservation Foundation, Environment Tasmania & The Wilderness Society 2011; Evans 2011e), as has spatial variation in the provision of ecosystem services (Williams 2011).

The spatial analysis of conservation values in the Tarkine has thus focussed on unweighted concentrations of specific values (e.g. forest values, ecosystem services, biodiversity, naturalness, key habitats, diversity, richness and uniqueness), with no measure of their significance level or inter-relationships (Harries 1995; Australian Conservation Foundation, Environment Tasmania & The Wilderness Society 2011; Evans 2011e; Williams 2011). Some data sources, such as vegetation maps, are of poor quality (Kirkpatrick 1998; McDonald 1999). The full extent of archaeological sites in the Tarkine has not been recorded (Harries 1995), with the Tasmanian Aboriginal Site Index being incomplete and based on recordings from the early 70’s and 80’s (Gall 2012, pers. comm., 21 March). New site recordings (Huys 2010) reflect the incomplete nature of archaeological data. There has been no mapping of Aboriginal cultural landscapes in the Tarkine.

As the conflict between conservation and development will ultimately only be resolved by political processes at multiple levels (Kirkpatrick 2012), the determination of the significance level (i.e. global, national, state, regional or local) of natural values is important for decision making and strategic planning (McDonald 2013) for the future of the Tarkine.

This chapter identifies and maps the spatial variation in conservation values individually, and as a whole, in the Tarkine study area and determines their significance and importance in global, national, state and regional contexts.

2.3 Methods

2.3.1 Identifying conservation values in the Tarkine

The conservation values of the Tarkine analysed in the present study were Aboriginal heritage, coastal interdigitation, rare and threatened biodiversity, callidendrous rainforest on basalt, rainforest river landscapes, largest contiguous rainforest, Meredith assemblage, wilderness and aesthetics, all of which were recognised to be of conservation significance in previous work (Stockton 1982; Cosgrove 1990; MacFarlane 1992; Harries 1995; Collett et al. 1998; Pedder, Hughes & Edwards 2007; Huys 2010; Evans 2011e; Williams 2011; Australian Conservation Foundation, Environment Tasmania & The Wilderness Society 2011; Australian Government 2011a, 2013a; Sims 2013).

2.3.2 Determining levels of significance

The level of significance of each conservation value was determined using any legal recognition of its importance, its area in relation to Tasmania, Australia and the world, its rarity, and its distinctiveness (Table 2-1, Table 2-2, Table 2-3, Table 2-4). Boolean (Boole 1848) (absent / present), proximity (Environmental Research Institute (ESRI) 2013) (near analysis), weighted concentration (ESRI 2013) (join count), weighted presence (ESRI 2013) (union) and weighted sum (Keeney & Raiffa 1976) scoring methods were used (Table 2-5). Scores were adjusted for each layer to create a range of 0 to 100. The scores for conservation values were then adjusted to reflect their significance level.

International conservation values retained their scores, national conservation values scores were reduced to 50% of their original value, State conservation value scores were reduced to 25% of their original value and regional conservation value scores were reduced to 12.5% of their original value. The adjusted scores for the conservation value layers were added using the ‘union’ tool. The sum for individual polygons varied from 2.08 to 292.19. These sums were adjusted to a range from 0 to 100 (Figure 2.5).

Table 2-1 – Methods used for determining the international significance scale of conservation values in the Tarkine.

Method	Value status	Spatial data
Aboriginal heritage		
Length of occupation of indigenous people and their impact on southern cool temperate landscapes compared at the global scale between Región de los Lagos, Chile and west coast South Island of New Zealand.	Informal measure of international significance supported in literature (Fletcher & Thomas 2010; Harries 1992; Hitchcock 2012; Law 2009; The Wilderness Society 1992, 2015).	Región de los Lagos: distribution of *Nothofagus* dominated rainforest islands, temperate closed forest from forests by major eocological domains (Food and Agriculture Organisation (FAO) 2000) in fire dependent plant communities, other land cover from forests by major eocological domains (FAO 2000). New Zealand: distribution of *Nothofagus* dominated rainforest islands, lowland beech forest from New Zealand Land Cover Database version 2 (Thompson, Grüner & Gapare 2003) in fire dependent plant communities, grasslands New Zealand Land Cover Database version 2 (Thompson, Grüner & Gapareet 2003) from confined to temperate oceanic ecofloristic zone of west coast of New Zealand, Global ecofloristic zones (United Nations Food and Agriculture Organisation (UNFAO) 2008).
Length of occupation of indigenous people and their impact on southern cool temperate landscapes compared at the national scale.	No national value status or significance available.	Cool temperate *Nothofagus* dominated rainforest islands, Vegetation Subgroups (Australian Government 2012c) in fire dependent plant communities, Sedgeland rushland peatland, Vegetation subgroups Australia (Australian Government 2012c).

Method	Value status	Spatial data
Aboriginal heritage (continued)		
Geographical clustering of large middens, hut depressions, seal hides, rock art and stone arrangements compared at the regional scale.	Informal recognition as above national significance threshold by the National Heritage Committee for middens, hut depressions and seal hides (Australian Government 2013c).	Digitisation of large middens, hut depressions, seal hides, rock art and stone arrangements (Stockton 1982; Richards & Sutherland Richards 1995; Sims 2013) with 100m buffers applied.
Geographical clustering of potential midden and associated artefact sites compared at the regional scale.	Informal recognition as above national significance threshold by the National Heritage Committee for middens (Australian Government 2013c).	Application of midden and associated artefact site modelling (Stockton 1982) with 100m buffers applied.
Boundary of the Western Tasmanian Aboriginal Cultural Landscape.	Formal, legal recognition of the national heritage significance of cultural landscape values through listing on the National Heritage Places Database (Australian Government 2013d).	Boundary of the Western Tasmanian Aboriginal Cultural Landscape, National Heritage Places Database (Australian Government 2013d).
Boundary of the Preminghana Indigenous Protected Area.	Formal, legal recognition of the national significance of environmental, heritage and cultural values to the Tasmanian Aboriginal people (Australian Government 1999).	Boundary of the Preminghana Indigenous Protected Area, Tasmanian Reserve Estate 2014 (Tasmanian Government 2015).

Method	Value status	Spatial data
Aboriginal heritage (continued)		
Boundaries of State Reserves (West Point and Sundown Point) and private reserves (Kings Run Private Reserve) for protection of Aboriginal cultural heritage[1].	Formal, legal recognition of the national and State significance of values consistent with the Western Tasmanian Aboriginal Cultural Landscape National Heritage Place (Australian Government 2013d).	Boundaries of West Point, Sundown Point and Kings Run, Tasmanian Reserve Estate 2014 (Tasmanian Government 2015).
Coastal interdigitation		
Geographical coincidence of coastal Precambrian surficial lithogy and small sand dunes on high-energy coasts compared at the global scale.	No international value status or significance available.	Distribution of coastal Precambrian surficial lithogy (Dürr & Meybeck 2005), small coastal dunes interspersed with sandy shores, rocky headlands (Martínez, Psuty & Lubke 2004) and annual mean wave power (Barstow et al. 2009)
Geographical coincidence of coastal Precambrian surficial lithogy and small sand dunes on high-energy coasts compared at the national scale.	Informal recognition as above national significance threshold by the National Heritage Committee (Australian Government 2013c). National significance supported by Kirkpatrick (2012).	Distribution of coastal Precambrian surficial lithogy, surface geology of Australia (Geoscience Australia 2012), small coastal dunes interspersed with sandy shores, rocky headlands (Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) 2009; Sharples et al. 2009) and annual mean wave power (Geoscience Australia 2010).

1 These reserves are included in the National Heritage Place, Western Tasmanian Aboriginal Cultural Landscape boundary.

Method	Value status	Spatial data
Coastal interdigitation (continued)		
Geographical concentration of coastal Precambrian hard rock platforms on high-energy coasts compared at the regional scale.	Formal (non-statutory) recognition as state significance for southern segments of the Tarkine coast listed on the Tasmanian Geoconservation Database (Tasmanian Government 2012c). State significance supported by Sharples (1996).	Digitised hard rock platforms from Bing Aerial Maps (ESRI 2012), near analysis ESRI ArcGIS 10.1
Biodiversity		
Geographical hotspots for threatened Dasyurid species compared at the global scale.	Formal (non-statutory) threatened status of *Sarcophilus harrisii, Dasyurus maculatus, Sminthopsis leucopus* and *Thylacinus cynocephalus*[2] by the International Union for Conservation of Nature (IUCN) Redlist (2013) recognised as internationally significant. International significance of the threatened hotspot status supported by Cardillo et al. (2006) and McQuillan et al. (2009).	Distribution of threatened Dasyurid species habitats (IUCN Redlist 2013).
Geographical concentration of threatened terrestrial animals by ecoregion compared at the global scale.	Informal measure of global concentrations of threatened terrestrial animals by ecoregion (Hoekstra et al. 2010).	Number of threatened terrestrial animals by ecoregion (Hoekstra et al. 2010).

2 Although Thylacinus cynocephalus is listed as extinct, numerous unconfirmed sightings have been recorded (Tasmanian Government 2013e).

Method	Value status	Spatial data
Biodiversity (continued)		
Geographical hotspots for threatened Dasyurid species compared at the national scale.	Formal, legal threatened status of *Sarcophilus harrisii* (endangered) and *Dasyurus maculatus subsp. maculatus* (vulnerable) by the Australian Government (2015b) under the EPBC Act 1999.	Distribution of threatened Dasyurid species habitats (IUCN Redlist 2013).
Geographical hotspots for threatened Dasyurid species compared at the state scale.	Formal, legal threatened status of *Sarcophilus harrisii* (endangered) and *Dasyurus maculatus subsp. maculatus* (rare) by the Tasmania Government (2015b) under the Threatened Species Protection Act 1995.	Distribution of threatened Dasyurid species habitats (IUCN Redlist 2013).
Geographical distribution of intact ecosystems (native vegetation and old growth forest) compared at the state scale.	Informal international significance (Michaels et al. 2010; Williams 2012).	Distribution of old growth forest (Regional Forest Agreement (RFA) 1997) and 'Fragstats' Tasmanian native vegetation (Michaels et al. 2010).
Geographical concentration of the number EPBC[3] listed species and communities occurring at 5km grid cells compared at national and state scales.	Formal, legal national listed threatened species (Australian Government 2013a).	Number of EBPC listed communities by grid cell (Australian Government 2013a).
Geographical weighted overlaps of threatened fauna, flora and vegetation communities species ranges and habitats compared at the regional scale.	Formal, legal national and State listed threatened species (Australian Government 2013a; Tasmanian Government 2013e).	Distribution of threatened species (Tasmanian Natural Values Atlas, Tasmanian Government 2013e; the Species Profile and Threats Database, Australian Government 2013a).

3 The Australian national threatened species legal framework, Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act).

Method	Value status	Spatial data
Callidendrous rainforest on basalt soils		
Geographical coincidence of tall and dense temperate and cool temperate rainforest (*Nothofagus* dominated) on basalt soils compared at global scale.	Informal international significance supported by (Hitchcock 2008, 2012).	South America: dense forest (100) clip from Forests of the World 2000, (FAO 2000) clipped to distribution of extant *Nothofagus* species (Dimitri 1972; Ibarra, Caldentey &Hidalgo 2007), Cretaceous Tertiary volcanics clip from South America Geological Map, (U.S. Geological Survey 1990), basalt plains (Zaffarana, Lagorio & Somoza 2012). New Zealand: New Zealand Native Forest (Land Information New Zealand 2013) clipped to New Zealand Temperate Rainforests (DellaSala 2010) clipped to distribution of extant *Nothofagus* species (Knapp et al 2005), basalt & igneous rocks clip from Land Resource Information System Spatial Data Layers, (Newsome, Wilde & Willoughby 2008).
Geographical coincidence of tall and dense temperate and cool temperate rainforest (*Nothofagus* dominated) on basalt soils compared at national scale.	Informal recognition by National Heritage Committee as above national threshold (Australian Government 2013c). National significance for its aesthetic value supported by Kirkpatrick (2012).	Cool temperate rainforest, warm temperate rainforest, tropical or subtropical rainforest clip from Vegetation Subgroups, (Australian Government 2012c) clipped to distribution of extant *Nothofagus* species (Knapp et al 2005), Czb mafic volcanic rocks clip from Surface Geology of Australia (Geoscience Australia 2012).
Geographical coincidence of tall and dense cool temperate rainforest (*Nothofagus* dominated) on basalt soils compared at state scale.	No state value status or significance available.	Callidendrous rainforest: M+ clip from TasVeg 2.0 (Tasmanian Government 2009), Basalt bedrock: Surface Geology of Australia (Geoscience Australia 2012).

Method	Value status	Spatial data
Rainforest river landscapes		
Geographical coincidence of cool temperate rainforest (*Nothofagus* dominated) flanking tannin stained fresh watercourses in non-alpine locales and river length compared at global scale.	No international value status or significance available.	New Zealand: Lowland Beech Forest from New Zealand Land Cover Database Version 2 (Thompson, Grüner & Gapareet 2003) clipped to *Sphagnum*-dominant communities (Whinham & Hope 2006) clipped to distribution of extant tannin waterways (Winterbourn & Collier 1987), clipped to 100m buffer from NZ River polygons (New Zealand Government 2015).
Geographical coincidence of cool temperate rainforest (*Nothofagus* dominated) flanking tannin stained fresh watercourses in non-alpine locales and river length compared at national and state scales.	Informal recognition by National Heritage Committee as above national threshold (Australian Government 2013c). National significance for its aesthetic value supported by Kirkpatrick (2012). No State value status or significance available.	Rainforest flanked rivers: Rainforest and related scrub from TasVeg 2.0 (Tasmanian Government 2009) clipped to 100m buffer from rivers The LIST hydline (Tasmanian Government 2012b).

Table 2-2 – Methods used for determining the national significance scale of conservation values in the Tarkine.

Method	Value status	Spatial data
Largest contiguous rainforest		
Geographical distribution of contiguous areas of temperate and cool temperate rainforest (*Nothofagus* dominated) and its coincidence with intact and old growth forest values compared at global scale.	No international value status or significance available.	World temperate: dense forest (100) clip from Forests of the World 2000 (FAO 2000) clipped to ecofloristic zone temperate oceanic & ecofloristic zone temperate mountain, Global ecofloristic zones (UNFAO 2008), clipped to World's Intact Forest Landscapes 2012 (Potapov et al. 2008). Cool temperate South America: dense forest (100) clip from Forests of the World 2000 (FAO 2000) clipped to ecofloristic zone temperate oceanic & ecofloristic zone temperate mountain, Global ecofloristic zones (UNFAO 2008), confined to cool temperate rainforest distribution (Kellogg 1992; World Wildlife Fund (WWF) 2000). Cool temperate New Zealand: New Zealand Native Forest (Land Information New Zealand 2013) clipped to ecofloristic zone temperate oceanic & ecofloristic zone temperate mountain, Global ecofloristic zones (UNFAO 2008), clipped to World's Intact Forest Landscapes 2012 (Potapov et al. 2008).
Geographical distribution of contiguous areas of temperate and cool temperate rainforest (*Nothofagus* dominated) and its coincidence with intact and old growth forest values compared at national scale.	Formal (non-statutory) national status as listed on the former Register of National Estate (Australian Government 2002a). Informal recognition by National Heritage Committee as above national threshold (Australian Government 2013c). National significance supported by Kirkpatrick and DellaSalla (2011) and Hitchcock (2012). National significance for its aesthetic value when combined with wilderness values supported by Kirkpatrick (2012).	Cool temperate rainforest, Vegetation subgroups Australia (Australian Government 2012c), clipped to World's Intact Forest Landscapes 2012 (Potapov et al. 2008).

Method	Value status	Spatial data
Largest contiguous rainforest (continued)		
Geographical distribution of contiguous areas of cool temperate rainforest (*Nothofagus* dominated) and its coincidence with intact and old growth forest values compared at State scale.	No state value status or significance available.	Rainforest and related scrub from TasVeg 2.0 (Tasmanian Government 2009) clipped to Old growth layer (Forestry Tasmania 2013b).
Meredith assemblage		
Geographical coincidence of button grass moorland, sedgeland, rushland, peatland on granite country, with high rainfall[4] compared at the State scale.	No international value status or significance available. Formal (non-statutory) national status as listed on the former Register of National Estate (Australian Government 2002a). Informal recognition by National Heritage Committee as above national threshold (Australian Government 2013c). National significance for its aesthetic value supported by Kirkpatrick (2012).	Sedgeland rushland peatland, Vegetation subgroups Australia (Australian Government 2012c) clipped to granite Surface Geology of Australia (Geoscience Australia 2012), and1600 mm to 3200 mm annual mean rainfall (Commonwealth Scientific and Industrial Research Organisation (CSIRO) 2010).

4 High rainfall was specified as areas that received over 1600 mm per annum.

Method	Value status	Spatial data
Meredith assemblage (continued)		
Geographical weighted overlaps of button grass moorland, sedgeland, rushland, peatland and granite batholith features on granite country, with high rainfall[5] compared at the state scale.	No state value status or significance available.	Moorland, sedgeland, rushland and peatland from TasVeg 2.0 (Tasmanian Government 2009) clipped to granite Surface Geology of Australia (Geoscience Australia 2012), coinciding with weighted features of granite batholiths Surface Geology of Australia (Geoscience Australia 2012) and1600 mm to 3200 mm annual mean rainfall (CSIRO 2010).

5 High rainfall was specified as areas that received over 1600 mm per annum.

Table 2-3 – Methods used for determining the state significance scale of conservation values in the Tarkine.

Method	Value status	Spatial data
Wilderness		
Geographical distribution of wilderness quality and areas using United Nations Environment Program (UNEP) & World Conservation Monitoring Centre (WCMC) (2005) and ecofloristic regions compared at the international scale.	Informal measure of wilderness values (UNEP & WCMA 2005; Lesslie, Taylor & Maslen 1995).	Boundary threshold of wilderness quality 14 and above, (UNEP & WCMC 2005; Lesslie, Taylor & Maslen 1995) coinciding with ecofloristic zones temperate mountain systems and temperate oceanic forest (FAO 2000).
Geographical distribution of wilderness quality and areas using Leslie et al. (1995) and ecoregions (Australian Government 2012b) compared at the national and state scales.	Informal measure of wilderness values (Comprehensive Regional Assessment (CRA)/RFA 1997; Australian Government 1997b, 2012a).	Boundary threshold of wilderness quality 14 and above, CRA/RFA (1997) / NWI map (Lesslie & Maslen 1995, Australian Government 1997b) coinciding with Australia's ecoregions (Australian Government 2012b).
Geographical distribution of wilderness areas using primitiveness and remoteness after (Mendel 2002; Kirkpatrick 1979) compared at the regional scale.	Formal (non-statutory) national status as listed on the former Register of National Estate (Australian Government 2002a). Informal recognition by National Heritage Committee as above national threshold (Australian Government 2013c). National significance for its aesthetic value when combined with the largest contiguous area of rainforest in Australia supported by Kirkpatrick (2012).	Roads, LIST transport segments (Tasmanian Government 2013f), Forest Vegetation Groups (Tasmanian Government 2012a).
Temporal geographical coincidence of wilderness areas compared at the regional level.	Formal (non-statutory) national status as listed on the former Register of National Estate (Australian Government 2002a). Informal recognition by National Heritage Committee as above national threshold (Australian Government 2013c). National significance for its aesthetic value when combined with the largest contiguous area of rainforest in Australia supported by Kirkpatrick (2012).	Digitisation of wilderness areas (Russell, Mathews & Jones 1979; Kirkpatrick & Haney 1980; Harries & Brown 1992; Lesslie & Maslen 1995; CRA/RFA 1997; Australian Government 1997b; Register of the National Estate (RNE) 1997; Mendel 2002) and wilderness quality and areas (North & Barker 2010).

Table 2-4 – Methods used for determining the regional significance scale of conservation values in the Tarkine.

Method	Value status	Spatial data
Aesthetics		
Geographical distribution of median slope proximal to inland water bodies compared at the international scale.	World Heritage List criteria *vii to contain superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance* (UNESCO 2016b).	Median terrain slope and inland water bodies (Van Velthuizen et al. 2007)
Geographical distribution of slope relief proximal to nonperennial inland water bodies, compared at the national scale.	Informal recognition by National Heritage Committee as above national threshold (Australian Government 2013c). National significance supported by Johnston, Young & Jones (2012).	Slope relief class and nonperennial inland water bodies (Gallant & Austin 2012).
Geographical scoring using weighted scenic elements (relative relief, lakes, coast, waterfalls, caves and vegetation diversity) compared at the state scale.	No state value status or significance available.	Scenic quality (Mendel & Kirkpatrick 1992).
Geographical scoring at 5 km x 5 km grid cells using weighted scenic elements (relative relief, lakes, coast, waterfalls, caves and vegetation diversity) after Mendel & Kirkpatrick (1992) compared at the regional scale.	No regional value status or significance available.	Relative relief: from 100 m contours (Tasmanian Government 2013a), lakes from TasVeg 2.0 AWU code Wetlands (Tasmanian Government 2009), waterfalls from Hydrographic Lines (Tasmanian Government 2012b), caves from Tasmanian Goeconservation Database V7 (Tasmanian Government 2012c) and vegetation diversity from TasVeg 2.0 vegetation description/title and Forest Group (Tasmanian Government 2009, 2012c).

Table 2-5 – Scoring methods for conservation values in the Tarkine.

Mapping layer	**Data inputs**	**Weight**	**Scoring system**
Aboriginal heritage	Boundaries of the Western Tasmanian Aboriginal Cultural Landscape, Preminghana Indigenous Protected Area, West Point, Sundown Point and Kings Run Reserves. Rainforest islands in fire dependent plant communities.	-	Boolean, present=100, absent=0, ***i***
Coastal interdigitation	Digitised hard rock platforms associated with deep local embayments	Units ranked by distance (m) between rock platforms, closest rock platforms = highest weight.	Proximity of rock platforms, scored in units of 6 up to maximum score 100, ***i***
Biodiversity	Threatened fauna, flora and vegetation communities species ranges and habitats.	Weighted sum of threatened species concentration (critically endangered habitats weight=4, endangered=3, vulnerable=2 and rare=1). Threatened flora and fauna point data attribute accuracy estimated at 95%, vegetation data sampled at 1:25,000, species ranges and habitats sampled at variable scales.	Weighted concentration of habitats, scored in units of 4 up to maximum score 100, ***i***
Callidendrous rainforest on basalt soils	Coincidence of callidendrous cool temperate rainforest and basalt bedrock.	-	Boolean, present=100, absent=0, ***i***
Rainforest river landscapes	Rainforest and related scrub confined to 100m buffer from rivers.	-	Boolean, present=100, absent=0, ***i***

Mapping layer	**Data inputs**	**Weight**	**Scoring system**
Meredith assemblage	Moorland, sedgeland, rushland and peatland coinciding with weighted features of granite country and granite batholiths and1600 mm to 3200 mm annual mean rainfall.	Weighted sum of vegetation, rainfall and geology concentration. Ranking based on percentage distribution of element in the Tarkine compared to Tasmania (2400mm mean annual rainfall=6, granite batholith=5, vegetation=4, 2000mm mean annual rainfall=3, 3200mm mean annual rainfall=2, 1600mm mean annual rainfall=1).	Weighted concentration of wet buttongrass moorland on granite country, scored in units of 16 up to maximum score 100, ***i***
Largest contiguous rainforest	Largest contiguous polygon of cool temperate rainforest. (Contiguous polygons = polygons ≤50m proximity).	-	Boolean, present=100, absent=0, ***n***
Wilderness	Areas of primitiveness, remoteness and wilderness buffer.	Overnight wilderness core areas (+8 hours hiking=3), day wilderness core areas (<8 hours hiking=2), wilderness buffer areas (<4 hours hiking=1).	Weighted presence of wilderness areas scored in units of 33 up to maximum score 100, ***s***
Aesthetics	Count of scenic elements: relative relief, lakes, coast, waterfalls, caves and vegetation diversity by 5 km x 5 km grid cell after Mendel & Kirkpatrick (1992). Areas of hardwood and softwood plantation, agricultural, urban and exotic vegetation polygons were excluded.	Sum of weighted elements by grid cell.	Weighted sum of scenic elements scored in units of 16 up to maximum score 100, ***r***

Score adjustments to reflect relative significance: ***i*** = internationally significant scores were multiplied by 1.0, ***n*** = nationally significant scores were multiplied by 0.5, ***s*** = state significant scores were multiplied by 0.25 and ***r*** = regionally significant scores were multiplied by 0.12.

2.4 Results

2.4.1 Internationally significant conservation values

The archaeological remains of Indigenous settlement on the coast are recognised to be nationally and globally outstanding (Hitchcock 2012). Approximately 12.5% (16 km^2) of the coastal area mapped as Aboriginal heritage included potential midden and artefacts sites, and 6.7% (14 km^2) included large conspicuous cultural landscape elements, which therefore represented a high density of cultural landscape values. Although individual polygons of cool temperate *Nothofagus*-dominated rainforest islands in fire-dependent plant communities shaped by Aboriginal occupation were mapped, the entire Tarkine landscape was considered to be of cultural landscape significance. Therefore no specific presence score was attributed consistent with mapping approaches used for biodiversity values where broad extant species (e.g. Dasyurid) ranges were not counted. The Tarkine represents 5% of the global land area of cool temperate *Nothofagus*-dominated rainforest islands in fire-dependent plant communities shaped by Aboriginal occupation. The Tarkine held 16.15% of the global distribution of this value and had similar patch density (ratio of 1:3.6 of rainforest islands to buttongrass moorland seas) and mean (0.19 km^2) and maximum patch size to the TWWHA (ratio of 1:3.9 of rainforest islands to buttongrass moorland seas) and mean patch size (0.15 km^2). The TWWHA had the largest (919 km^2) area of cool temperate *Nothofagus*-dominated rainforest islands in fire-dependent plant communities shaped by Aboriginal occupation, followed by the Tarkine. The areas in New Zealand and Region de Los Lagos were smaller, less dense and had much briefer human occupation than the Tasmanian cases. The Aboriginal heritage conservation value in the Tarkine was therefore considered of international significance.

The Tarkine has 14.74% of the global distribution of *Nothofagus*-dominated cool temperate rainforest flanking tannin-stained fresh watercourses, the longest (16 km) and longest mean (2.3 km) river length and most geographically dispersed rivers globally for this conservation value. Whilst New Zealand and the TWWHA had larger total areas of rainforest river landscapes, they were more geographically concentrated and were shorter in river length. The rainforest river landscapes conservation value in the Tarkine was considered of international significance due to the longer river stretches here than elsewhere.

The Tarkine has 0.5% of the global distribution of Dasyuridae habitats (including non-threatened species) and 11.84% of the global distribution of threatened Dasyuridae habitats. It has 16.47% of the global distribution of four or more threatened Dasyuridae habitats making its concentration high. The area of four or more threatened Dasyuridae habitats was larger in the Tarkine than the TWWHA, which had 5,250 km^2. The Wet Tropics World Heritage Area had 3,073 km^2 of two or more threatened Dasyuridae habitats. The Tarkine contains 35% of the remaining Devil facial tumour disease free area in Tasmania. The biodiversity conservation value in the Tarkine was considered to be of international significance.

The Tarkine has 7.16% of the global distribution of coastal interdigitation and 35% of the distribution in the southern hemisphere. The Tarkine held more coastal interdigitation than the TWWHA. The Tarkine has the largest area of this value in the southern hemisphere and is second to the largest area in Greenland. The coastal interdigitation conservation value was considered to be of international significance.

The Tarkine has 1.98% of the global distribution of callidendrous rainforest on basalt soil and 4.10% of intact old growth callidendrous rainforest on basalt soil. There were 258 km^2 of callidendrous rainforest on basalt soils in World Heritage Areas in New Zealand, 10 km^2 in the Gondwana rainforests of Australia World Heritage Areas and 1 km^2 in the TWWHA. None of the callidendrous rainforest on basalt soils in southern South America was within World Heritage Areas. The area of callidendrous rainforest on basalt soils and intact old growth callidendrous rainforest on basalt in the Tarkine is larger compared to those in World Heritage Areas and therefore considered of international significance. The Tarkine represented 100% of the national distribution of callidendrous rainforest on basalt soil in wilderness areas of quality of 14 and above.

2.4.2 Nationally significant conservation values

Scleromorphic heath vegetation on wet granite country is extant worldwide (Gole 2006; Bargmann & Kirkpatrick 2015) but the Australian distribution contains exclusively endemic species (Balmer 2007) and those associated with rocky outcrops have unique physiognomy (Clarke P, 2002), therefore relevant for comparison at the national scale. The Meredith assemblage holds 62.59% of the national distribution of scleromorphic heath vegetation on wet granite country. There were 0.9 km^2 of the Meredith assemblage in the TWWHA. The second largest area of distribution was in the Heemskirk Range.

Australia’s largest contiguous area of cool temperate rainforest is located in the Tarkine. It is 20% of the size of the largest contiguous area of cool temperate intact, old growth *Nothofagus*-dominated rainforest in southern South America. The second largest area of cool temperate rainforest in Australia was 494 km^2 located in TWWHA. The largest area of cool temperate rainforest on the main island of Australia was 6 km^2. The largest contiguous rainforest conservation value was considered to be of national significance.

2.4.3 Conservation values of State significance

The Tarkine is 0.002% of the global, 0.03% of the national and 8.08% of the State distribution of wilderness, making the distribution of wilderness in the Tarkine significant at the State level. The Tarkine held 0.03% of the total national distribution of wilderness quality 14 and above and 4.31% of the total in the temperate broadleaf and mixed forests ecoregion.

2.4.4 Regionally significant conservation values

The Tarkine represented 5.7% of the state distribution of weighted scenic scores of 16 and above making the aesthetics conservation value significant at a regional scale. The Tarkine did not have any areas with the higher range of values.

2.4.5 Concentrated areas of conservation values

Some conservation values did not include co-incidence of multiple polygons and therefore did not include degrees of concentration (e.g. Aboriginal heritage, callidendrous rainforest on basalt, rainforest river landscapes, largest contiguous rainforest) (Table 2-5). These conservation values were mapped as having a maximum score of 100 (Figure 2.1, Figure 2.3 (largest contiguous rainforest)).

Aboriginal heritage values covered 208 km^2, with large middens (>1,000 m^2), rock carvings and stone arrangements covering 14.43 km^2. The largest midden was 74,534, the smallest 18 m^2, the mean 823 m^2 and the standard deviation 4.7 m^2. A total of 258 midden polygons were mapped, with 31 (12%) being classified as large. A total of 3,423 interdigitation polygons (5.61 km^2) of hard rock, platforms, shelf and reefs were identified. Interdigitation polygons occurred in six discrete areas (Figure 2.2).

Twenty-four rare or threatened species of fauna, 58 species of flora and 22 vegetation communities covered 2,926 km^2, with the areas with the highest scores close to the coast (Figure 2.2). Callidendrous rainforest on basalt soils covered 330 km^2, while rainforest river landscapes covered 1,452 km^2. The mean length along rivers was 2.5km, with the Little Donaldson River the longest (24 km). The largest contiguous area of rainforest in Australia was 1,517 km^2 (Figure 2.3). The Meredith assemblage totalled 108 km^2, with 60% (65 km^2) of the distribution confined to the Meredith Range. The largest polygon was 53 km^2 located in the Meredith Range, with second largest areas located south of the Heemskirk Road (Figure 2.2).

Five wilderness cores were identified, covering 518 km^2 with wilderness buffers totalling 1,895 km^2 (Figure 2.3). The Bertha, Upper Savage River and Meredith Range areas included 8-hour wilderness cores totalling 50.91 km^2. A total of 7,225 km^2 of high aesthetic value was identified. Four concentrated areas of scenic quality were identified along the Tarkine coast. The highest scored areas (100) were located at Rocky Cape, followed by Ahrgerg Bay, West Point and Rebecca Lagoon (Figure 2.3).

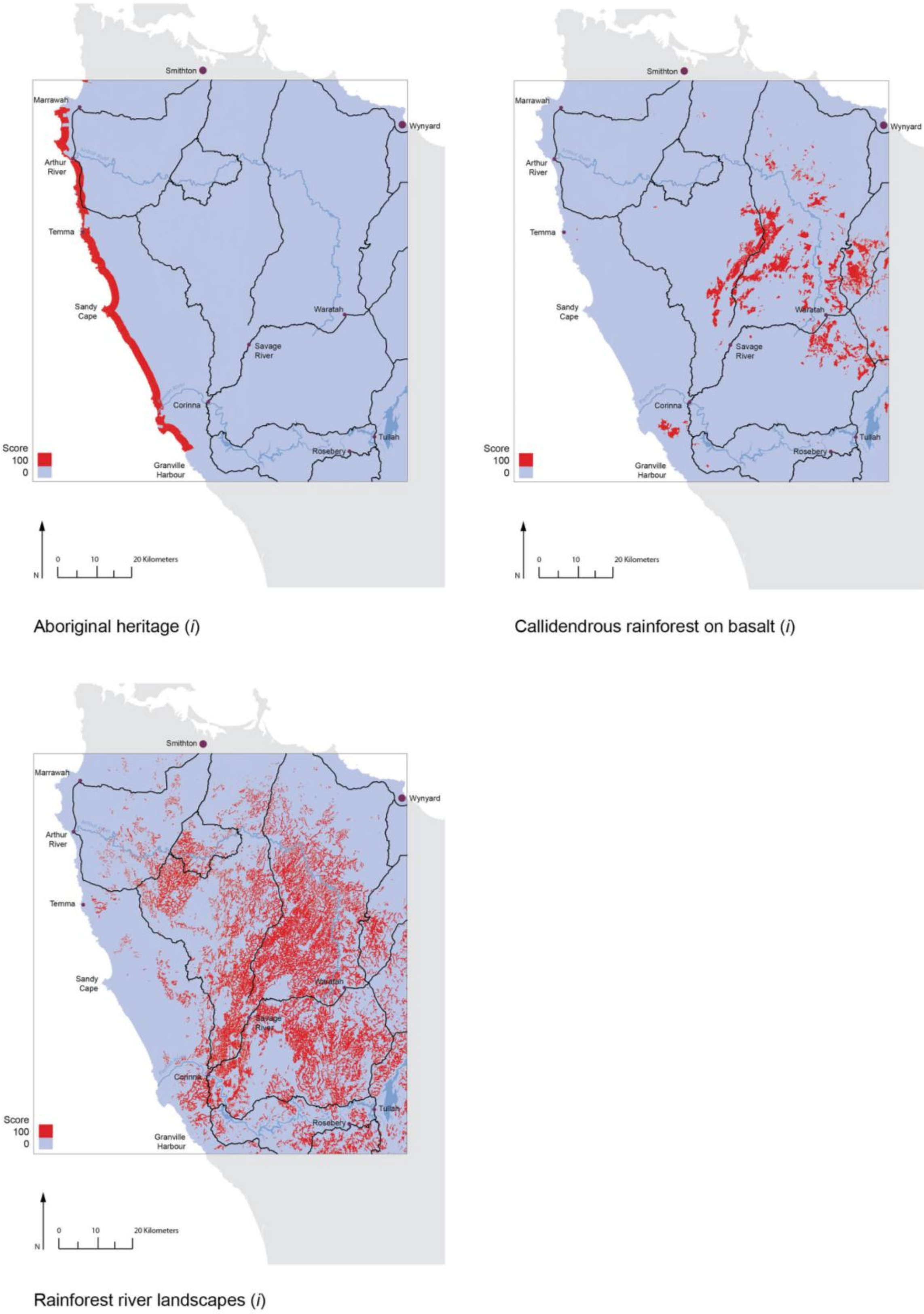

Figure 2.1 – Mapped conservation values in the Tarkine.

(*i* = internationally significant values).

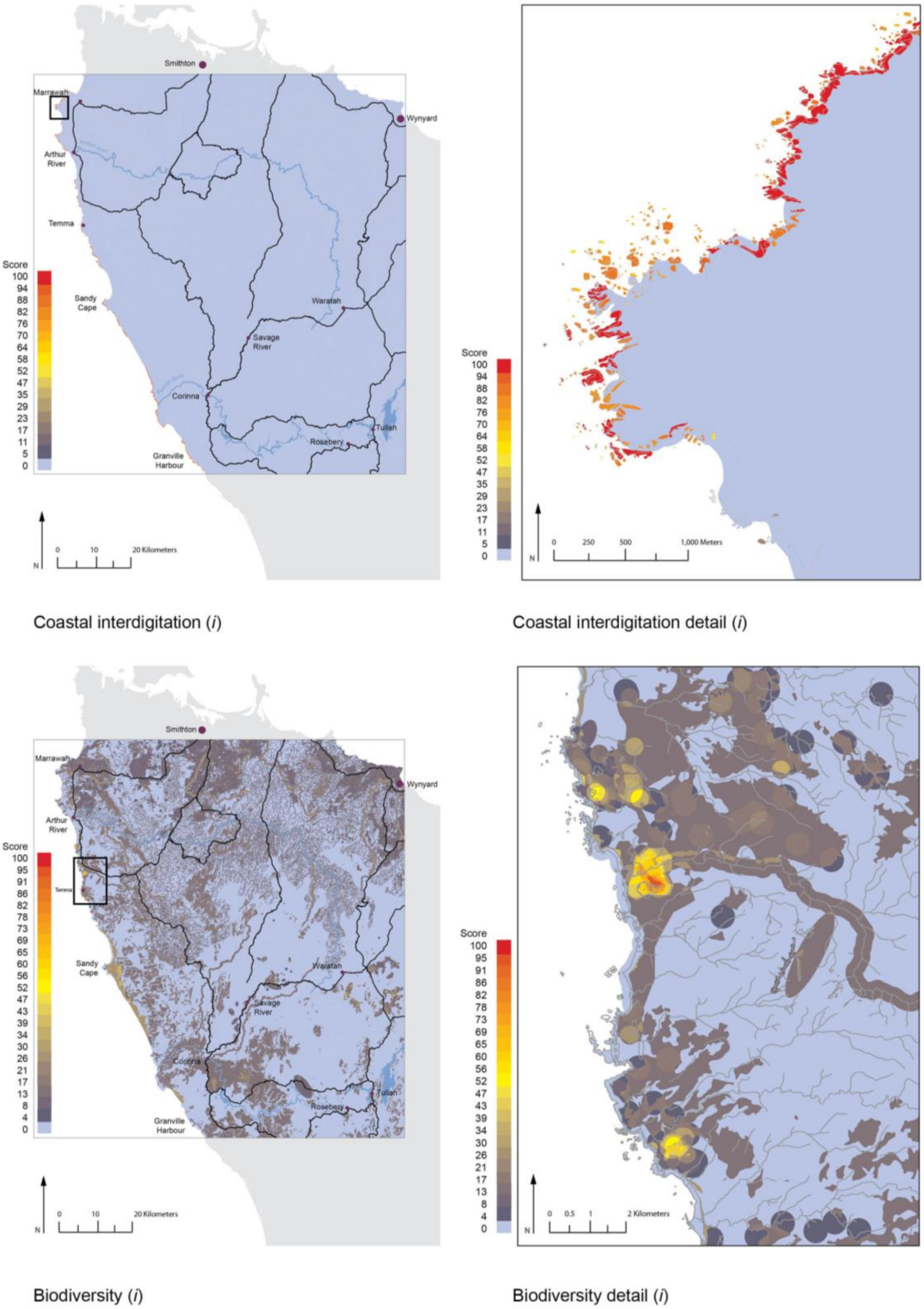

Figure 2.2 – Mapped conservation values in the Tarkine.

(*i* = internationally significant values).

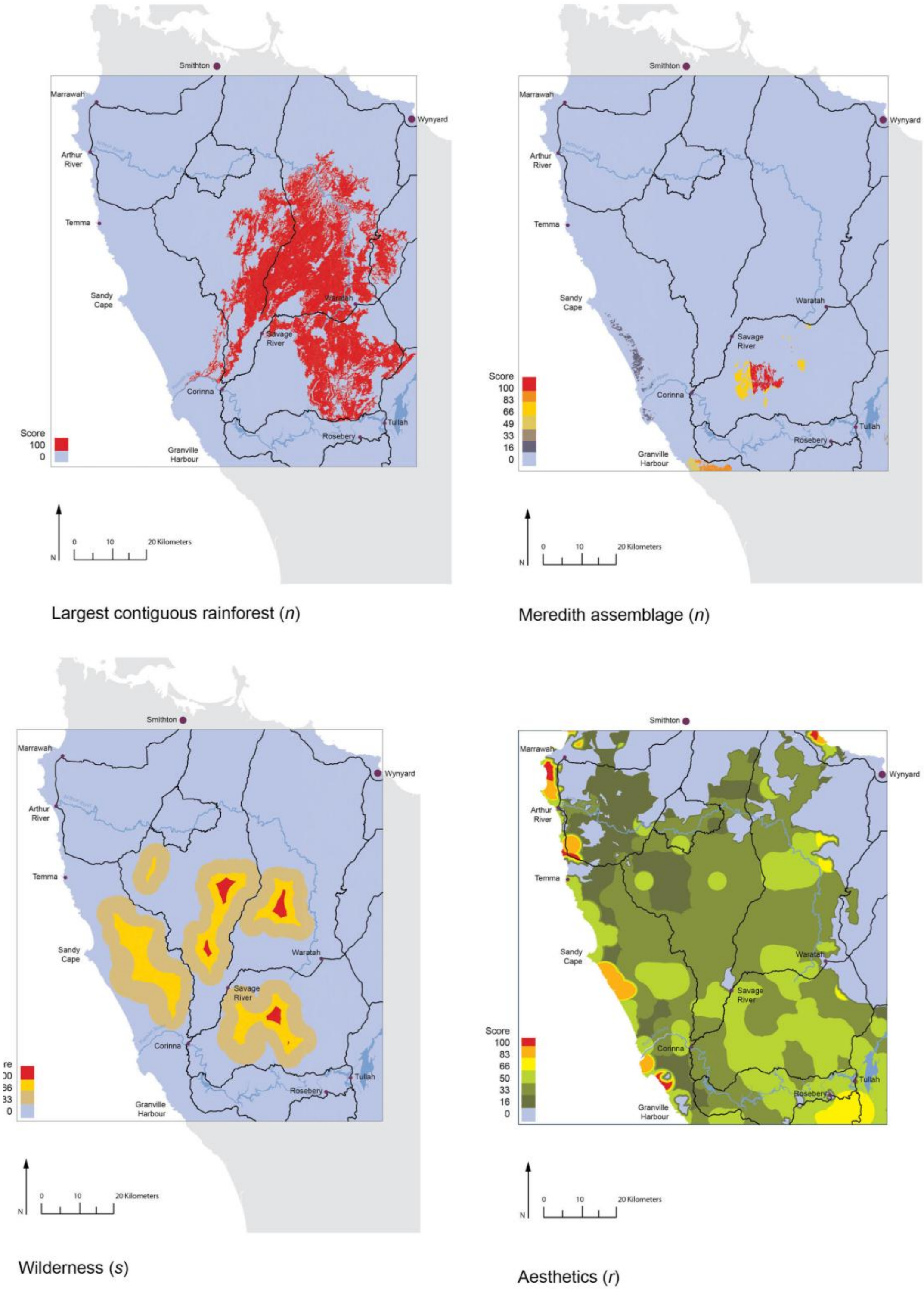

Figure 2.3 – Mapped conservation values in the Tarkine.

(n = nationally significant values, s = state significant values, r = regionally significant values).

Table 2-6 – Comparative geographical distribution of conservation values in the Tarkine.

	Tarkine	International		National		State		Regional	
Value	**(km²)**	**(km²)**	**(%) *i***	**(km²)**	**(%) *n***	**(km²)**	**(%) *s***	**(km²)**	**(%) *r***
Aboriginal heritage (Cool temperate *Nothofagus* dominated rainforest islands in fire dependent plant communities shaped by Aboriginal occupation)	258	1,598	16.15	1,443	17.88	1,443	17.88	258	3.04
(Boundaries for listed areas)	208	-	-	-	-	-	-	208	2.45
(Clustering of large conspicuous cultural landscape elements)	14	-	-	-	-	-	-	14	0.17
(Potential midden and artefact modelling)	26							26	0.31
Coastal Interdigitation (Rock platforms)	5.61	-	-	-	-	-	-	5.61	0.06
(Precambrian surficial lithogy and small sand dunes on high-energy coasts)[a]	132	1,856	7.16	380	34.96	380	34.96	132	100.00

	Tarkine	**International**		**National**		**State**		**Regional**	
Value	**(km^2)**	**(km^2)**	**(%) *i***	**(km^2)**	**(%) *n***	**(km^2)**	**(%) *s***	**(km^2)**	**(%) *r***
Biodiversity (Threatened Dasyuridae habitats)[b]	**8,487**	71,675	11.84	71,675	11.84	64,445	13.17	8,487	100.00
(Threatened terrestrial animals by ecoregion)[c]	**8,487**	31,465,371	0.02	4,270,766	0.19	97,855	8.67	8,487	100.00
(EPBC listed species & communities)[d]	1,044	-	-	375,688	0.27	31,242	3.34	1,044	12.30
(EPBC listed species & communities)[e]	7,443	-	-	7,486,635	0.09	66,336	11.22	7,443	87.70
(Intact ecosystems) old growth	2,673	-	-	-	-	9,266	28.85	2,673	31.49
(Intact ecosystems) native vegetation	7,073	-	-	-	-	50,504	14.00	7,073	83.33
Weighted concentration of habitats	2,926	-	-	-	-	-	-	2,926	34.47
Callidendrous rainforest on basalt soils (*Nothofagus* dominated tall and dense temperate and cool temperate rainforest on basalt soils)	330	16,659	1.98	457	72.43	389	85.05	330	3.90
(Intact forest / old growth)	226	5,521	4.10	238	95.17	238	95.17	226	2.67
(Occurring in wilderness quality 14 and above)	124	6,308	1.96	124	**100**	124	**100**	124	1.46

	Tarkine	**International**		**National**		**State**		**Regional**	
Value	**(km^2)**	**(km^2)**	**(%) *i***	**(km^2)**	**(%) *n***	**(km^2)**	**(%) *s***	**(km^2)**	**(%) *r***
Rainforest river landscapes (*Nothofagus* dominated cool temperate rainforest flanking tannin stained fresh watercourses in non Alpine locales)[f]	410	2,787	14.74	1,198	34.28	1,198	34.28	410	4.84
(*Nothofagus* dominated cool temperate rainforest flanking tannin stained fresh watercourses in non Alpine locales)[g]	1,452	-	-	4,222	34.41	4,222	34.41	1,452	17.12
(Intact / old growth *Nothofagus* dominated cool temperate rainforest flanking tannin stained fresh watercourses in non Alpine locales)[f]	278	1,958	14.20	841	33.06	841	33.06	278	3.28
Largest contiguous rainforest (*Nothofagus* dominated contiguous areas of temperate and cool temperate rainforest)[h]	1,517	40,976	3.70	1,517	**100.00**	1,517	**100.00**	1,517	17.87
(*Nothofagus* dominated contiguous areas of temperate and cool temperate rainforest coinciding with intact and old growth forests values)[h]	1,194	6,036	19.78	1,194	**100.00**	1,194	**100.00**	1,194	14.07

	Tarkine	**International**		**National**		**State**		**Regional**	
Value	**(km^2)**	**(km^2)**	**(%) *i***	**(km^2)**	**(%) *n***	**Value**	**(km^2)**	**(km^2)**	**(%) *i***
Meredith assemblage (Buttongrass moorland, sedgeland, rushland, peatland on granite country)	108	-	-	338	31.99	331	32.71	108	1.28
(Buttongrass moorland, sedgeland, rushland, peatland on granite country with high annual rainfall)	108	-	-	173	62.59	172	62.61	108	1.28
Wilderness (Wilderness quality 14 and above in temperate mountain systems and temperate oceanic forest ecofloristic zones)	1,064	2,815,897	0.38	16,272	6.53	13,163	8.08	1,064	12.54
(Wilderness quality 14 and above)	1,064	69,766,986	0.002	3,566,574	0.03	13,163	8.08	1,064	12.54
(Wilderness quality 14 and above in temperate broadleaf and mixed forests ecoregions)	1,064	-	-	24,651	4.31	13,163	8.08	1,064	12.54
(Wilderness areas using primitiveness and remoteness)	518	-	-	-	-	-	-	518	6.10

	Tarkine	International		National		State		Regional	
Value	**(km^2)**	**(km^2)**	**(%) *i***	**(km^2)**	**(%) *n***	**Value**	**(km^2)**	**(km^2)**	**(%) *i***
Aesthetics (Steep to very steep median slope and inland water bodies)[j]	0.00	163,312	0.00	5.20	0.00	0.00	0.00	0.00	0.00
(Gentle to moderate median slope and inland water bodies)[k]	62	579,311	0.011	1,169	5.38	558	11.26	62	0.74
(Very steep median slope and inland water bodies)[l]	3.78	-	-	95	3.98	41	9.21	3.78	0.04
(Steep median slope and inland water bodies)[m]	57	-	-	2,466	2.31	560	10.16	57	0.67
(Moderate median slope and inland water bodies)[n]	96	-	-	10,435	0.92	1,463	6.59	96	1.14
(Weighted scenic elements: relative relief, lakes, coast, waterfalls, caves and vegetation diversity)[o]	1,300	-	-	-	-	22,800	5.70	7,700	15.32
(Weighted scenic elements: relative relief, lakes, coast, waterfalls, caves and vegetation diversity)	7,225	-	-	-	-	-	-	7,225	85.12

i = percentage of international distribution of value occurring in the Tarkine, ***n*** = percentage of national distribution of value occurring in the Tarkine, ***s*** = percentage of state distribution of value occurring in the Tarkine and ***r*** = percentage of the total area of Tarkine that value occurs. **a** = metric is calculated in linear kilometres, **b** = two or more threatened Dasyuridae species, **c** = ten to twenty globally threatened terrestrial animals by ecoregion, **d** = ten to nineteen nationally listed threatened species and communities, **e** = one to nine nationally listed threatened species and communities, **f** = comparison used river polygons at 1:50k scale, **g** = comparison used river polygons at 1:25k scale, **h** = percentage of distribution indicates the comparative size of the largest contiguous polygons of rainforest at each significance level, **j** = median terrain slope of 45 or more degrees coinciding with inland water bodies with 4 kilometre buffer applied, k = median terrain slope of 30 to 45 degrees coinciding with inland water bodies with 4 kilometre buffer applied, **l** = median terrain slope of 61 to 76 degrees coinciding with inland water bodies with 2.5 kilometre buffer applied, **m** = median terrain slope of 45 to 56 degrees coinciding with inland water bodies with 2.5 kilometre buffer applied, **n** = median terrain slope of 36 to 45 degrees coinciding with inland water bodies with 2.5 kilometre buffer applied, **o** = weighted scenic scores of 16 and above. Highest values are shown in bold.

2.4.6 Combined significance and concentration of conservation values

The mapped conservation values were unioned to determine areas of concentrated conservation value (Figure 2.4). Over 97% (7,325 km^2) of the total area of combined conservation significance had significance scores of 50 or less. One point four percent (108 km^2) of the total area of combined conservation significance had a score of 60 or above. Polygons with significance scores of 80 to 100 were confined to the Pipeline Corridor and Savage River National Park areas and featured dense clustering of callidendrous rainforest on basalt and rainforest river landscapes. Polygons with significance scores of 60 to 70 involved dense clustering of coastal interdigitaion and Aboriginal heritage.

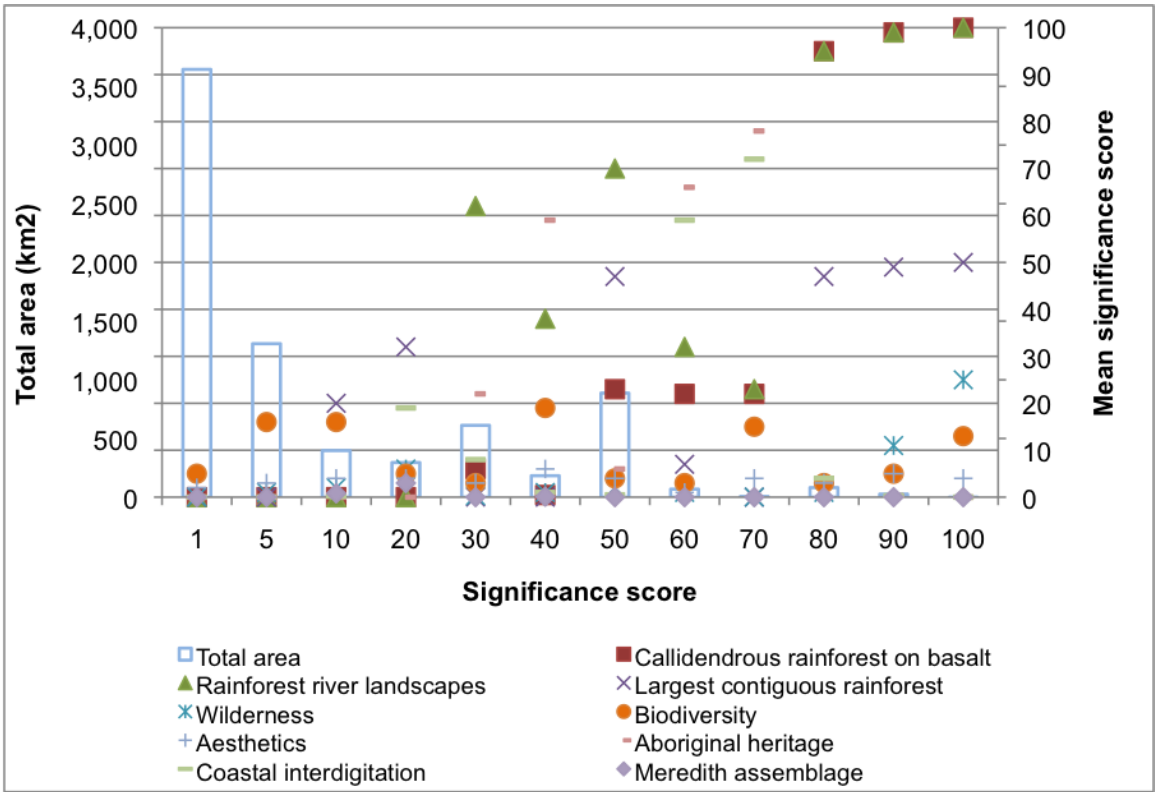

Figure 2.4 – Distribution of combined significance score polygons.

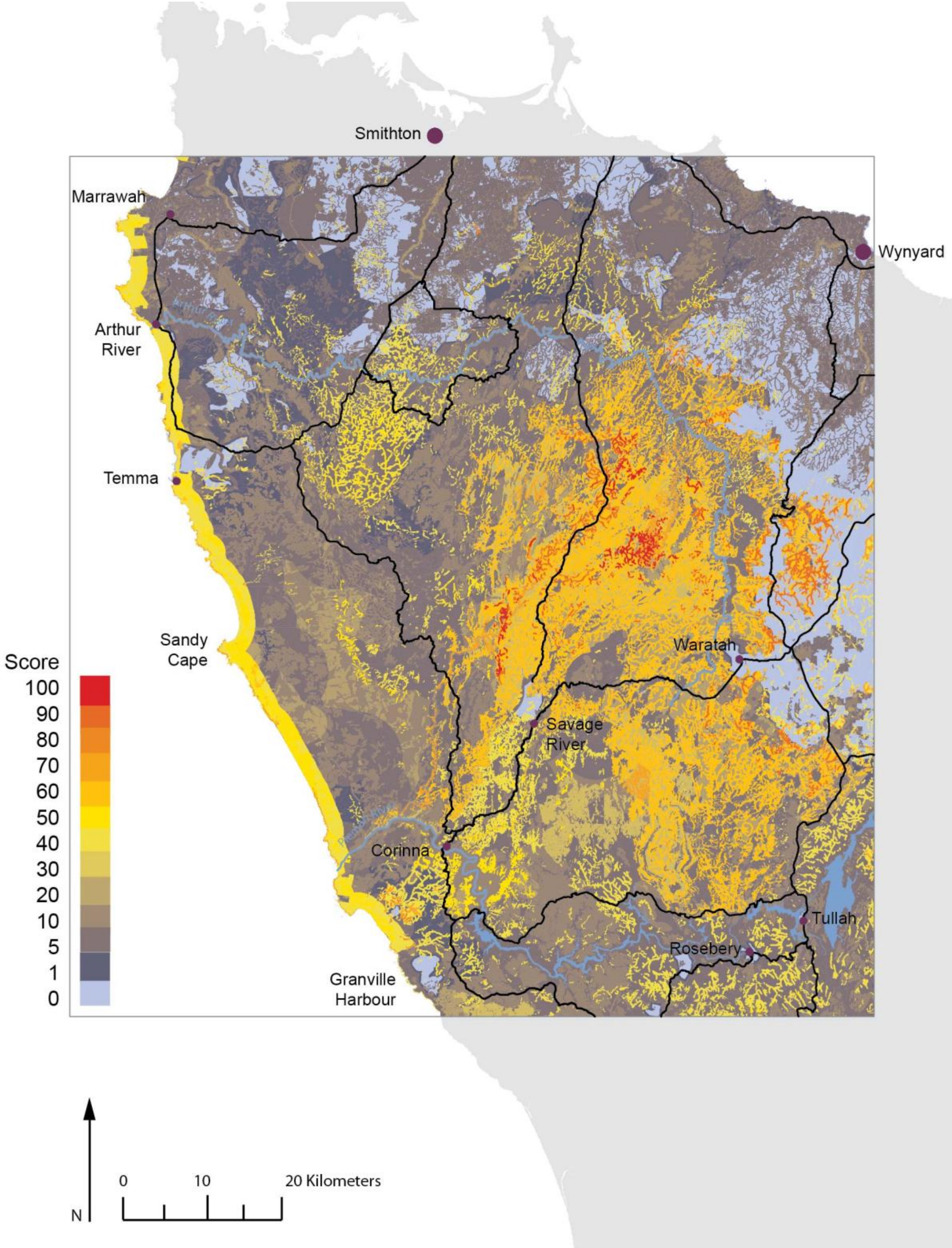

Figure 2.5 – Combined conservation value in the Tarkine.

2.5 Discussion

2.5.1 World Heritage significance of conservation values

The Tasmanian cool temperate *Nothofagus*-dominated rainforest islands in fire dependent plant communities shaped by Aboriginal occupation is outstanding globally due to its age c 35 ka (Cosgrove 1999; Fletcher & Thomas 2010) and integrity, as cultural burning was practiced in the landscape only 200 years ago (Plate 1). This attribute strengthens the case for World Heritage significance under criterion v, '…to be an outstanding example of a traditional human settlement, land-use, or sea-use which is representative of a culture (or cultures), or human interaction with the environment, especially when it has become vulnerable under the impact of irreversible change' (UNESCO 2016b). The current distribution pattern of moorlands and rainforest may depend on the reintroduction of Indigenous practices, or analogues thereof. Changes in the distribution of rainforest and fire-resistant sedgeland have occurred in the last 200 years with changes in anthropogenic burning (Bowman et al. 2013; di Folco & Kirkpatrick 2013; Fletcher et al. 2013; McWethy et al. 2013), making this Aboriginal heritage value vulnerable.

Modelling of potential midden and associated artefact sites using inputs from Stockton (1982) revealed greater possible distribution of sites (161%) than previously reported (Stockton 1982; Richards & Sutherland Richards 1995), supporting the notion that additional research is likely to increase validation of the international significance of Aboriginal cultural heritage values in the Tarkine (Hitchcock 2012). Whilst shell middens are common elsewhere in the world (Ceci 1984; Àlvarez et al. 2011; Stein & Taylor 2012), they have diverse origins (Ceci 1984; Àlvarez et al. 2011) and diverse cultural associations. The number of large middens in the Tarkine is higher than in the TWWHA (Hitchcock 2012). The middens are distinctive in Australia for their representation of sedentary lifestyle and lack of fish waste (Legge 1928; Pulleine 1929; Hiatt 1967; Lourandos 1970; Bowdler 1974; Jones 1974; Stockton & Rodgers 1979; Huys 2010; Australian Government 2013e).

The interdigitation of land and water on the Tarkine coast has been informally recognised as above national significance threshold (Australian Government 2013c) and celebrated for its unusual rugged, wild and distinct coastal aesthetic (Dombrovskis 2006; Bell 2013) (Plates 3, 4). The co-occurrence of strand plain depositional environments bound by wave-dominated deltas on a high-energy coast that occurs in the Tarkine has not been observed elsewhere in Australia (Harris & Heap 2003). Hitchcock (2012) argues that the high-energy coastline of the Tarkine with its huge waves, long beaches and treeless coastal heath plains satisfy World Heritage criterion vii. It is suggested in this thesis that this coastal interdigitation fulfils World Heritage criterion vii. The interdigitation of the coast represents a spiritual aesthetic extending back to Indigenous peoples and their sense of place as the rocky outcrops were a vital habitat for food sources and had direct visual links to the giant middens flanking the water edge. This cultural and spiritual aesthetic value is more strongly represented in the Tarkine than the TWWHA due to the greater extent and co-incidence of middens and coastal interdigitation. Whilst it was concluded that the aesthetic value of the Tarkine was of regional significance, this conclusion was based on scenic quality methods (weighted landscape elements) as distinct from cultural aesthetic inputs.

The Tarkine's long black reflective rivers flowing through rain-forested slopes have been informally recognised as aesthetically outstanding at above the national significance threshold (Australian Government 2013c) and have been suggested to satisfy World Heritage criterion vii (Hitchcock 2012). The results in this thesis are consistent with Hitchcock (2012) in that the rainforests framing undisturbed rivers in the Tarkine are more common and better developed than those in the TWWHA and are the longest globally, therefore satisfying World Heritage criterion vii. Reflections of delicate rainforest vegetation on slow dark waters are often depicted in images of the Donaldson and Rapid Rivers (Blakers 2008; Evans 2011c) (Plates 9, 10).

The results in this thesis are consistent with the conclusion that the Tarkine satisfies World Heritage criterion x as a wild habitat for threatened Dasyuridae (Law 2009; Hitchcock 2012; The Wilderness Society 2015) and is an internationally significant threatened hotspot for Dasyuridae (Cardillo et al. 2006; McQuillan et al. 2009) (Plate 5). The Tarkine holds internationally significant biodiversity values through extant intact ecosystems (native vegetation and old growth forest) that are largely undisturbed, buffered from development and have condition and integrity large enough to sustain ongoing ecological and biological processes (Michaels et al. 2010; McDonald & McCaffrey 2011; Hitchcock 2012; Williams 2012) These values have been argued to meet World Heritage criterion x (Hitchcock 2012). The results in this thesis indicated that the coastal ecosystems of the Tarkine provide important hotspot habitat for threatened fauna and flora (c.f. Schahinger 2007; Department of Primary Industries, Parks, Water and Environment (DPIPWE) 2009; Evans 2011e) and are of high ecosystem services value (c.f. Williams 2011). With biodiversity loss rates increasing globally (Ceballos et al. 2015) and calls to include irreplaceability as an indicator for biodiversity status for World Heritage criterion x (Le Saout et al. 2013), the biodiversity significance of the Tarkine is likely to increase in the future.

The callidendrous rainforest on basalt in the Tarkine has been informally recognised as above national significance threshold for aesthetic values (Australian Government 2013c) and argued as internationally significant by Hitchcock (2008; 2012) (Plate 7). The results of this thesis indicate that callidendrous rainforests on basalt occurring in wilderness areas are confined to the Tarkine in Australia. Whilst the callidendrous rainforest on basalt in the Tarkine supports a globally distinct centre of distribution for rare and unusual species of lichen (Kantvilas 2003a, 2003b; Australian Government 2013c) it is visually similar to forests in New Zealand (Kirkpatrick & DellaSala 2011). However, the aesthetically distinct moss clad *Atherosperma moschatum* (Mead 2004, Plate 8), is absent from callidendrous rainforest in New Zealand (Kirkpatrick & DellaSala 2011). The *Nothofagus*-dominated cool temperate rainforests of New Zealand and southern South America range in maximum height from 10 to 50 m (Smale, Bergin & Steward 2012; Stein 2015), making the *Nothofagus cunninghamii* rainforests of the Tarkine commensurate in maximum height (30 to 40 metres). Although the results in this thesis indicate that old growth callidendrous rainforest on basalt is rare globally and is poorly represented in TWWHA (Williams 2012) it is not considered to be of international significance because of the widespread nature of similar forests on fertile substrates.

2.5.2 Contestation of wilderness values and their significance

Recent draft changes to the TWWHA management plan have sparked debate in Tasmania about the preservation and value of wilderness (Burden 2015; Hardy & Pearson 2015; Smith 2015a). Some see the privileging of economic development over the intangible values of wilderness as a direct threat to the integrity of the World Heritage listing (Baxter 2013; Hallinan & McCreath 2014; Kirkpatrick 2015). Others see potential for sustainable tourism to increase knowledge of the values of the TWWHA (Hardy & Pearson 2015). The term ‘wilderness’ is thought by some Indigenes, but not others, to be incompatible with Aboriginal ‘country’ (Rose 2012; Robin 2014; Hardy & Pearson 2015). Some view ‘wilderness’ as ‘…just another name for dispossession and exclusion for Australian Aboriginal people and cultural practices’ (Lee 2015). Regardless of this contestation of a word, areas that are currently described as wilderness in Tasmania are an exemplar of the types of country that were once permanently occupied by Aboriginal people prior to European invasion (Australian Government 2010; Kiernan 2014; UNESCO 2016a). Having country that is remote from mechanised access is a value in itself and helps maintain ecological values and functions (Mittermeirer et al. 2003; Mackey & Rogers 2015). Remote landscapes are vital in supporting ongoing evolutionary processes (Dudley et al. 2012; Heller & Hobbs 2014).

The wilderness areas of the Tarkine have been informally recognised for their natural landscapes, habitat values and coincidence with Australia's largest tract of cool temperate rainforest (Peter Bennett & Associates & Tasmanian Woodchip Export Study Group 1985; Harries & Brown 1995; Hitchcock 2012; Australian Government 2013c; The Wilderness Society 2015) (Plates 1, 12).

Wilderness values are most contested on the Tarkine coast, where illegal mechanised ORV access continues to expand and degrade wilderness and Aboriginal cultural values (Jones 2007; Coles 2014). Future road closures/openings and other developments can decrease or increase wilderness area and quality very easily. Track closures have the potential to yield wilderness gains in primitive areas where fewer human impacts exist and where closures are greater than 5 km in distance from disturbances. Mead (2015) argues that as a result of ongoing dilapidation of forestry roads and bridges and, if tenure is secured, the wilderness areas in the Tarkine have the potential to expand, as occurred in the TWWHA. Closure of coastal four-wheel drive tracks has the potential to increase wilderness quality in the Tarkine and help protect Aboriginal cultural values.

2.5.3 Representation of values using the simple additive weighted method

The simple additive weighted (SAW) method (Keeney & Raiffa 1976) is the most commonly used technique for solving multiple criteria decision-making problems (Mendas & Delali 2012; Salehi & Izadikhah 2014). SAW methods have been criticised as misrepresenting the significance of singular and important values that occur within themselves and may lead to false results (Kirkpatrick 1983; Malczewski 1999). In geographic information systems (GIS) tools, although the SAW method provides a proportional linear transformation of the raw data (Söylemez & Düzgün 2009) it assumes linearity and additivity of attributes, which may lead to inadequate representation of values (Malczewski 1999). For example, the linearity assumption infers that the desirability of a value is constant (e.g. 10 ha of land is valued the same regardless if it is added to 100 ha or 1000 ha) (Malczewski 1999). The additivity assumption precludes interaction or complementary effects between two attributes (Malczewski 1999). Although the role of weights is disputed in SAW methods (Coutinho-Rodrigues, Simão & Antunes 2011) it is considered a risk-neutral technique and a mid way approach between conjunctive and disjunctive approaches (Eastman 2009; Greene et al. 2011). Sensitivity analyses can be used to determine the effect of change of weights on final SAW scores (Memariani, Amini & Linezhad 2009; Johnston & Graham 2013) and are useful where there is uncertainty in defining the importance of values or procedures for assigning weights are ad hoc (Malczewski 1999; Ozturk & Batuk 2011).

The potential for misrepresentation of single values by using the simple additive weighted method is minimal in this current research, as higher weighted values clustered in similar areas and were complementary. The highest combined conservation scores were derived from the related callidendrous rainforest on basalt soils, rainforest river landscapes, largest contiguous rainforest, and biodiversity (rainforest riparian habitats). Similarly, on the coast, higher values were derived from the complementary archaeological and cultural landscapes and coastal interdigitation. However, not all values were commensurate, for example the largest contiguous rainforest in Australia (Plates 11, 12) was categorised as nationally significant, although it contained values that were of World Heritage significance (rainforest river landscapes and biodiversity). There were some values that were of World Heritage significance (Aboriginal heritage, coastal interdigitation, some areas of biodiversity and rainforest river landscapes) that did not have any nationally significant values. A systematic procedure was used in this thesis for determining the level of significance (based on distribution, formal recognition and quality at relevant scales) and significance scoring (incremental increases of 100% per scale threshold) which precluded uncertainty in defining the importance of values under investigation.

Trainor (2006) argues that diverse realms of value (such as spiritual and moral valuing) are comparable, but not commensurable or reducible. Stephenson (2008) argues that cultural landscapes cannot be measured by predetermined landscape value typologies, rather the dynamic and temporal dimensions of cultural landscapes need to be understood through cultural forms, relationships and practices of the past and present. However, cultural landscapes have been quantified using landscape variables (Wrbka et al. 2004), anthropogenic and natural landscape change (Bender et al. 2005), pollen-landscape relationships (Broström et al. 1989) and participatory mapping of cultural ecosystem services (Plieninger et al. 2013). Places frequented by Indigenes are regarded as valuable as are Indigenous sacred sites, which have also been mapped and quantified (Anderson et al. 2005; Taçon 2010).

2.5.4 Aboriginal cultural landscape values

Whilst SAW methods in this current research have highlighted two main clusters of higher value (inland rainforest and coast) the international significance of the landscape in a holistic cultural sense has not been measured. Archaeological, abiotic (coastal interdigitation) and biotic (vegetation burning patterns) inputs have been used in this theis to attempt to measure Aboriginal cultural landscape values. These inputs do not capture the complete value of the cultural landscape. There have been recommendations that the Aboriginal cultural values of the TWWHA and any possible extensions be evaluated (Rao, Lopoukhine & Jones 2008; UNESCO 2013; Australian Government 2012d, 2015c; International Council on Monuments and Sites (ICOMOS) 2014; Sturmer 2014). The Aboriginal cultural values of the TWWHA have been judged and weighted less than the natural values, resulting in a natural-cultural dualism (Lee 2016). In order to address methodological limitations and cultural misrepresentations of cultural landscape valuing, equitable consultation frameworks are required (Natcher 2001). Approaches that recognise the contribution of Aboriginal land practices in contributing to biological diversity (Buggey 1999) and the role of cultural ecosystem services and biocultural diversity (Schaich, Bieling & Plieninger 2010; Hill et al. 2011) may be useful in future cultural landscape assessments of the Tarkine.

The results in this thesis indicate that the Tarkine has internationally significant values that may meet World Heritage criteria iii, v, vi, vii and x. They are consistent with the conclusion of others that the Aboriginal heritage of the Tarkine is globally significant (Harries 1995; The Wilderness Society 1992; Law 2009; Fletcher & Thomas 2010; Hitchcock 2012) and meets World Heritage criteria iii, v and vi (Hitchcock 2012).

Chapter 3 Determining the pattern of optimal economic use in the Tarkine

3.1 Chapter overview

In the previous chapter, the heritage importance of conservation values was assessed. This chapter determines the pattern of optimal economic use in the Tarkine. It reviews methods for assessing the most economic mix of land use and valuation approaches and the extant economic values of the Tarkine. The methods section describes the data collection inputs used to map the natural resources of economic value. The economic valuation methods are explained whereby costs are subtracted from revenues, including costs for the transport network and industry output multipliers. Detail on how the mapped natural resources have been valued is given in the methods section, including; specific data inputs, net present valuation and application of industry output multipliers. The existing mineral resource provides data inputs for the valuing of prospective mineral areas. Justification of the selection of discount rates, time frame variables, industry output multipliers and an analysis of development priorities are also explained in the methods section of this chapter. The results report the distribution and valuing of the development resources (minerals, wood, tourism and carbon), development priorities for their compatible distribution and spatial sensitivity analysis using industry output multipliers. The discussion section of the chapter examines the development resources, the social relevance of development priorities, the potential for spatial variation and the degree of conflict between economic uses.

3.2 Introduction

There is a large literature dealing with the general problem of finding the most economic mix of land use in a region where some uses are incompatible. Values are assigned to resources and trade-offs between uses calculated (Nelson et al. 2009; Das & Chopra 2011; Goldstein et al. 2012; Temper & Martinez-Alier 2013). Cost-benefit analysis (CBA) with different discount rates and time frames can be used to compare the economic viability of alternative land uses in any one place (de Groot et al. 2012). Alternative future modelling and development scenarios are used as the context for quantification of economic impacts of different patterns of land use change (Steinitz et al. 2005; Nelson et al. 2009; Goldstein et al. 2012).

Whilst CBA is the single most widely used method to quantify the economic value of a project or land use (Dixon et al. 2006), it has been criticised as limited as it does not take into account the economic values of other land uses that it may preclude (Ross 1995) or adequately reflect a realistic benefit or cost. The net present value (NPV) approach inherent in CBA may not aid conservation or environmental justice outcomes, as it does not account for the plurality of non-economic values. Cost-benefit analysis can therefore strengthen cultural inequality and negative distribution of resources (Temper & Martinez-Alier 2013). Whilst common practice in mining valuation, the NPV technique is unreliable, as the single valuation approach ignores the range of probable non-economic risks associated with mining development (Longergan 2002). Furthermore, the NPV technique when applied to tourism development does not adequately reflect the incidental consequences (non-monetary and social cost factors) of increased visitors (Omotayo Brown & Kwansa 1999).

The discount rate and time frame variables used in CBA can dramatically affect the valuation result (Faber & Hemmersbaugh 1993; Ludwig, Brock & Carpenter 2005). Longer time periods and smaller discount rates favour future generations, and shorter time frames and higher discount rates favour the present generation. Therefore it is important to consider intergenerational equity through the use of social discount rates to provide a balanced valuation of the public good benefits as opposed to individual time preferences of project proponents (Scarborough 2011). Some argue that it is more appropriate to use a declining-certainty-equivalent discount rate than a constant discount rate when considering NPV in an intergenerational context, as it can capture the ambiguity of future consumption growth rates (Arrow et al. 2012).

In the present chapter, the development and land use potential of an area labelled the Tarkine in northwest Tasmania (Figure 3.1) is examined. Prior research suggests a range of development values: minerals, wood, tourism and carbon, all of which are recognised to be of economic value (Mesibov 2002; Timber Workers for Forests 2004; SCA Marketing 2007; Economic and Market Development Advisers (EMDA), Moore Consulting & SCA Marketing 2007a, 2007b; Felmingham & Wadsley 2008; Leesong 2009; Cradle Coast Authority (CCA) 2008; Bacon, Calver & Pemberton 2008; Tasmanian Government 2011a; Jordan, Pullinger & Bayley 2012; May et al. 2012; Macintosh 2012a, 2012b; Large & McNeil 2012; Felmingham 2013; Jordan 2015). The Tarkine has also been valued for its contribution to the regional economy for hydroelectric power generation, kelp processing, wild fisheries, honey production, water supply and recreational activity (Campbell-Ellis 2008).

The Tarkine has been acknowledged for its potential importance for carbon markets (Williams 2011), an economic value potentially incompatible with the other economic values of the region. It is therefore important to know which land use has the highest economic return in which parts of the region. This chapter quantifies potential economic activities in the Tarkine and establishes the spatial patterns of best economic use using a NPV approach under various realistic combinations of discount rates and periods, with and without multiplier effects.

This chapter assesses the distribution and economic valuing of development resources including minerals, wood, tourism and carbon. Although conservation values, including sites that met world heritage criteria and locations within important habitat for biodiversity, were mapped and quantified in the previous chapter, such natural assets are not subject to economic valuation in the current chapter. It is acknowledged that conservation values elsewhere, such as world heritage sites (Noonan 2003; Kim, Wong & Cho 2007; Choi et al. 2010; Voltaire 2016), biodiversity and ecosystems (Pearce & Moran 1994; Nunes & van den Bergh 2001; de Groot et al. 2012; Kumar 2012) have been assessed for economic value using various methods (e.g. contingency valuing, choice modelling and restoration cost estimation). In this chapter, tourism and carbon assets rather than natural heritage and biodiversity values are subject to economic valuation for several reasons. The economic valuation of biodiversity has been criticised as not representing the full range of benefits that may exist (Nunes & van den Bergh 2001) and has reliability problems causing double counting (Fu et al. 2010) and was therefore not chosen for this study. Further, the distribution of tourism values encapsulates sites that meet world heritage criteria and thus does not require additional valuing. The *a priori* workshop materials and potential conservation and development trade-off options (discussed in the next chapter) were limited by time and operationalisation constraints and therefore additional economic valuing of sites that met world heritage criteria and biodiversity was not warranted.

3.3 Methods

3.3.1 Data collection

Economic value was determined by mapping the resource and attributing revenue and fixed cost values to polygons (Table 3-1, Table 3-2, Table 3-3, Table 3-4). Weighted concentration (ESRI 2013) (join count), weighted presence (ESRI 2013) (union), weighted sum (Keeney & Raiffa 1976) and proximity (ESRI 2013) (near analysis) scoring methods were used to map the net present value (NPV) of the mineral resources (Table 5). Boolean (Boole 1848) (absent / present) and proximity (ESRI 2013) (near analysis) scoring methods were used to map the NPVs of the wood and tourism resources (Tables 7 and 8). The boolean (Boole 1848) (absent / present) method was used to map the NPV of the carbon resource (Table 10).

Revenue inputs were sourced from commodity prices, royalties, average yields, mean gross operating profits and latent demand. Cost inputs were transport infrastructure life cycle costs, amortisation of road infrastructure costs based on axle loads, resource transport costs, resource harvest costs and fire management costs (Tables 1, 2, 3, 4). Revenue and cost inputs were publicly available data.

3.3.2 Data analysis

The economic value of each resource was determined by subtracting relevant total costs incurred by each development activity from relevant revenues. Total costs were: a) maintenance and capital improvement of the transport network, b) extraction and transport costs to the nearest port and c) management and protection of assets. Revenues were: a) mineral and wood revenues, b) visitation yield and c) carbon trading revenues. Direct output multipliers (type 1) (Leontief 1966) were used for each resource industry type.

Additional economic valuing and benefits such as downstream processing, visitor growth and carbon trading price growth have not been considered in this present analysis. It was assumed that development activity would take place regardless of the existing reserve system or environmental regulation in order to capture the greatest possible spatial and economic extent of development activity. Capital and maintenance costs for existing and new bridges have not been accounted for in the present analysis.

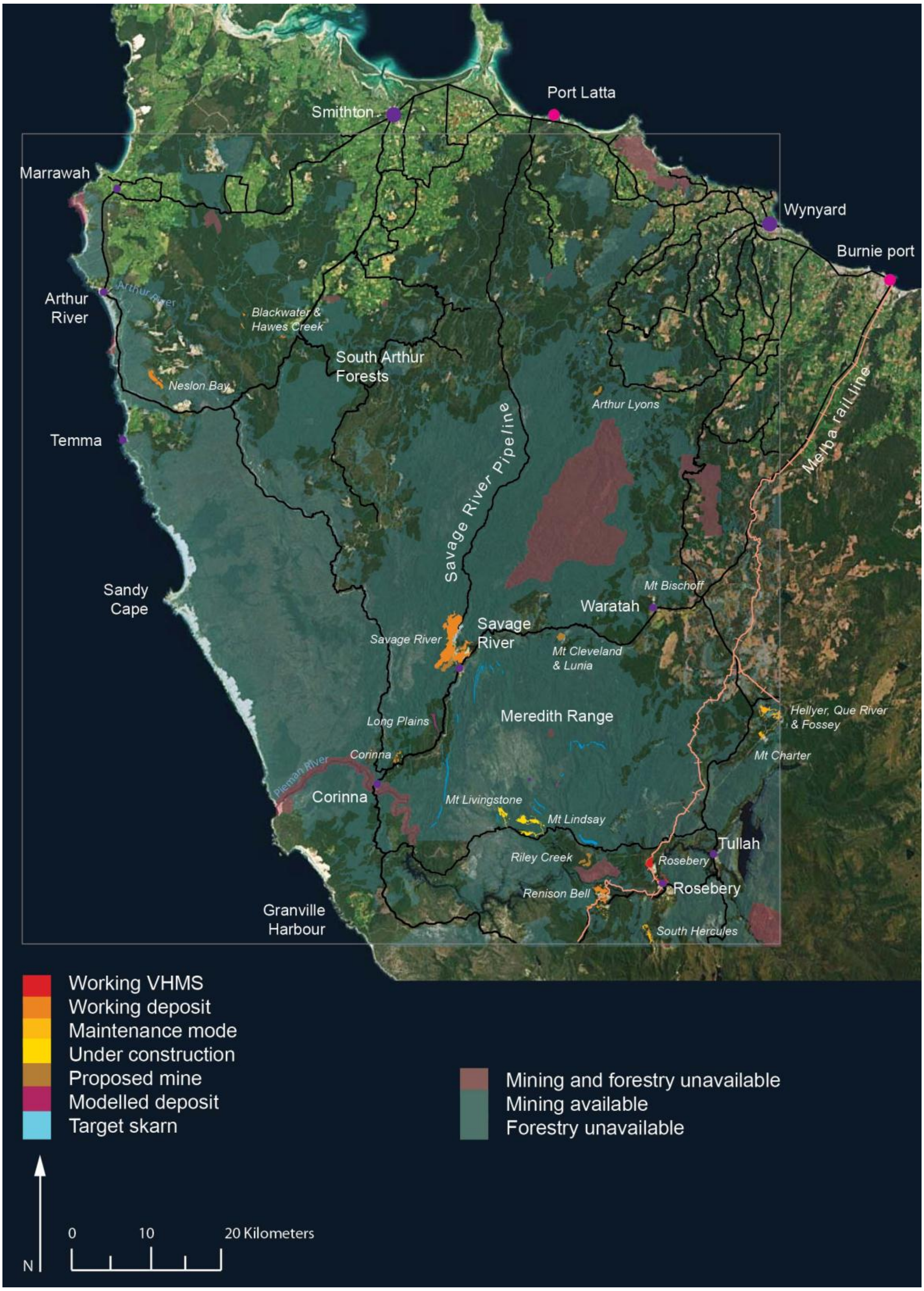

Figure 3.1 – Study location, existing mineral development and reserve status.

Table 3-1 – Mineral resource data inputs.

Revenue inputs	**Data**
Mineral resource	
Known deposits (Working volcanogenic massive sulphide deposits, world class deposits, existing working deposits and mines under construction and mineral deposits in maintenance mode).	Spatial data, existing net present values, capital and operational costs, production tonnages, mineral types and mineral commodity prices (Vaughan 2006; Bass Metals 2006, 2013; Bacon, Calver & Pemberton 2008; Mineral Resources Tasmania (MRT) 2008, 2011 & 2013; Moisier, Berger & Singer 2009; GHD 2009; RM Research 2011; Shree 2011; Macquarie 2012; Beacon Hill 2012; Minerals and Metals Group (MMG) 2012; Grange 2013a, 2013c; Canaccord Genuity 2013; Metals X 2013a, 2013b). Point data attribute accuracy estimated at 95%. Footprints of existing mines digitised using Bing Aerial Maps (ESRI 2012), sampled at 1:5,000.
Proposed mines.	Spatial data, proposed net present values, capital and operational costs, production, mineral types and mineral commodity prices tonnages (Venture 2008, 2012; Skwarnecki 2011; Mancala 2012; RM Research 2012; Beacon Hill 2012, 2014; Elementos 2013; Stellar 2013; Beer & Co 2013; Proactive Investors 2013a, 2013b, 2013c; Grange 2013b). Footprints of proposed mines digitised using mine proposals, sampled at variable scales.
Potential deposits.	Spatial data, new modelled and drill tested deposits (Bass Metals 2006; Elementos 2013; Grange 2013b). Footprints of potential mines digitised using mine reports, sampled at variable scales.
Mineral potential under exploration.	Spatial data and drill tested exploration target skarns (Venture 2008, 2012). Footprints of target skarns and ore bodies digitised using mine reports, sampled at variable scales.
Geological potential (high and medium mineral potential possible).	Spatial data (Large & McNeil 2012), sampled at 1:500,000 and 1:250,000.
Potential reworking of past deposits.	Spatial data (MRT 2013b), point data attribute accuracy estimated at 95%.

Revenue inputs	Data
Pre-mining in-ground values.	Estimates (Large & McNeil 2012).
Mineral royalties.	Reported figures, legislated charge structures and royalty calculation equation (Grange 2013a; Tasmanian Government 2014; MRT 2013a; Australasian Legal Information Institute 2014).
Rail bulk freight charges.	(Otway & Ferreira 1992; Australian Government 2013b).
Output multiplier.	(Australian Bureau of Statistics (ABS) 1990; Rayner & Bishop 2013; Davidson & de Silva 2011; Kookana, Duc Pham & Quinn 2014).
Fixed cost inputs	**Data**
Rail and road transport network.	Spatial data Transport segments, the List (Tasmanian Government 2013f), vector data attribute accuracy estimated at 90%, originally sampled at 1:5,000 and 1:25,000.
Maintenance of the Melba rail line.	(Australian Rail Track Corporation (ARTC) 2008; Tasmanian Government 2012d).
Capital costs of above.	(Engineers Australia 2010; Martin 2011; SKM 2012; Tasmanian Government 2012d).
Ore transport tones p.a. on Melba Line.	(Bass Metals 2006, 2013; MMG 2012; Metals X 2013a).
Annual average daily traffic (AADT).	(Tasmanian Government 2013d).
Percentage of wear and tear on the road network imposed by ore transport.	(Martin 2000; Hore-Lacy, Thoresen & Martin 2012).
Maintenance and capital costs of existing access roads.	(McNamara 2003; Jahren et. al. 2005; Tasmanian Government 2008; State Grants Commission 2012; Forestry Tasmania 2009, 2012; National Highway Coalition 2013).
Maintenance and capital costs of new access roads, including high productivity vehicle (PV) capital upgrades and maintenance.	(McNamara 2003; Jahren et. al. 2005; Tasmanian Government 2008; State Grants Commission 2012; Forestry Tasmania 2009, 2012; SKM 2012; National Highway Coalition 2013).

Table 3-2 – Wood resource data inputs.

Revenue inputs	Data
Wood resource	
Forest resource mapping.	Spatial data, Tasmanian forest group layer (Tasmanian Government 2012a), TasVeg 2.0 (Tasmanian Government 2009), Deep Red Myrtle resource layer (Australian Government 2002b), Regenerated forest layer (Forestry Tasmania 2013c) and Old growth layer (Forestry Tasmania 2013b). Vegetation data sampled at 1:25,000.
Sustainable harvest yields (mean wood yields per hectare over time for each forest type) and average rotation length (years).	(Whiteley 1999).
Wood yields and sustainable harvest rates for the tall *Eucalyptus obliqua* forest resource.	(Beadle 2007; Harwood & Kirkpatrick 1978).
Wood yields and sustainable harvest rates for the Deep Red Myrtle (tall *Nothofagus cunninghamii)* forest resource.	(Mesibov 2002).
Wood yields and sustainable harvest rates for Tall *Acacia melanoxylon* forest resource.	(Gleason 1986).
Biological production function model.	(Campbell 1999).
Market value of the resource mill door landed value (MDLV) of the timber per cubic metre according to each species and green weight market value of the timber (excluding costs) per cubic metre according to each species.	(Mesibov 2002; ABARES 2012; Industry Edge 2013; Forestry Tasmania 2013a; Tasmanian Blackwood 2013).
Output multiplier.	(Hayter 2001; Felmingham 2002; Forest Industries Association of Tasmania (FIAT) 2002).

Wood resource	
Fixed cost inputs	**Data**
Road transport network.	Spatial data Transport segments, the List (Tasmanian Government 2013d), vector data attribute accuracy estimated at 90%, originally sampled at 1:5,000 and 1:25,000.
Maintenance existing access roads and new access roads.	Forestry Tasmania (2009, 2012).
Capital costs of above.	(McNamara 2003; Tasmanian Government 2008; State Grants Commission 2012; Forestry Tasmania 2009 and 2012; National Highway Coalition 2013).
Variable cost inputs.	Data
Harvest costs (stumpage).	(Brown et al. 2001; Mesibov 2002; TFGA 2011).
Haulage costs.	(Australian National University (ANU) Forestry 1999; Industry Edge 2013).

Table 3-3 – Tourism resource data inputs.

Revenue inputs	Data
Tourism resource	
Total visitor nights were based on the 2013 season TVS data.	(TV Analyser 2014).
Latent demand for visitation in the Tarkine.	(EMDA, Moore Consulting & SCA Marketing 2007b).
Industries receiving revenue from direct visitor expenditure.	(Nichol, Shi & Campi 2013b)
Expected average gross operating profit margin for industries receiving revenue from direct visitor expenditure.	(IFC 2004; ABS 2012; Colliers International 2014; Humke, Hilbruner & Hawkins 2015).
Core appeal of old growth rainforest and wilderness guided tours for key market segments of the Tarkine.	(Inches 2010; Fry 2014).
Old growth rainforest.	Forestry Tasmania (2013b).
Wilderness areas.	in this thesis.
Output multiplier.	(Nichol, Shi & Campi 2013b; Kookana, Duc Pham & Quinn 2014).

Tourism resource

Fixed cost inputs	**Data**
Road transport network.	Spatial data Transport segments, the List (Tasmanian Government 2013d), vector data attribute accuracy estimated at 90%, originally sampled at 1:5,000 and 1:25,000.
Annual average daily traffic (AADT).	(Tasmanian Government 2013d).
Percentage of wear and tear on the road network imposed by visitors.	(Martin 2000; Hore-Lacy, Thoresen & Martin 2012).
Maintenance and capital costs of existing access roads.	(McNamara 2003; Jahren et. al. 2005; Tasmanian Government 2008; State Grants Commission 2012; Forestry Tasmania 2009, 2012; National Highway Coalition 2013).

Table 3-4 – Carbon resource data inputs.

Revenue inputs	Data
Carbon resource	
Forest type classes suitable for carbon sequestering potential.	Tasmanian forest group layer (Tasmanian Government 2012a), TasVeg 2.0 (Tasmanian Government 2009), Regenerated forest layer (Forestry Tasmania 2013c) and Old growth layer (Forestry Tasmania 2013b). Vegetation data sampled at 1:25,000.
Maximum carbon density (t/ha CO_2e), carbon content (%t/m^3) and turn over of carbon to ground (%/yr) estimates for live vegetation, debris and soil in native forests and plantations.	(May et al. 2012).
Moorland carbon mass and carbon accumulation estimates.	(di Folco &Kirkpatrick 2011, 2013).
Native grassland carbon mass and carbon accumulation estimates.	(Prober & Lunt 2009; Neal et al. 2013; Snyman, Ingram & Kirkman 2013).
Agricultural lands carbon sequestration estimates.	(Luo, Wang & Jianxin Sun 2010; Sanderman, Farquharson & Baldock 2010; Doyle et al. 2014).
Agricultural land.	TasVeg 2.0 (Tasmanian Government 2009).
Volume weighted average carbon price of $13.95 per carbon credit.	(Talberg & Swoboda 2013; Carbon Market Institute 2015).
Output multiplier.	(Ibarrarán & Boyd 2010).

Carbon resource

Fixed cost inputs	**Data**
Road transport network.	Spatial data Transport segments, the List (Tasmanian Government 2013d), vector data attribute accuracy estimated at 90%, originally sampled at 1:5,000 and 1:25,000.
Maintenance existing access roads.	Forestry Tasmania (2009, 2012)
Capital costs of above.	(McNamara 2003; Tasmanian Government 2008; State Grants Commission 2012; Forestry Tasmania 2009, 2012; National Highway Coalition 2013).
Forest protection (fire management).	Forestry Tasmania (2012).
Carbon trading costs (Audits, technical support and administration).	(May et al. 2012).

3.3.3 Valuing the existing mineral resource

Mines that were currently not operating were included in the assessment assuming that future operation might be possible as mineral markets change. It was assumed that the Hellyer, Fossey and Que River mines would continue to utilise the Melba rail line rather than transport ore by road. It was assumed that the Venture mines (Mt Livingstone, Mt Lindsay and Riley Creek mines) would choose to transport ore by road rather than utilise the Savage River Pipeline or the Melba line. Post-production mine rehabilitation costs have not been considered in this present analysis. It was assumed that costs for rehabilitation bonds were included in net present valuation of mines. It was also assumed that NPV estimates and all inputs relating to the economic value of mineralisation and mines are compliant with the Australasian Code for Reporting of Exploration Results, Mineral Resources and Reserves (JORC 2012).

Standard transport infrastructure valuation methods (Transport & Main Roads 2011; Peel 2014; Terrill, Emsile & Coates 2016) and mining operating profit valuation methods (ABS 2013) were used in the following equation to quantify the present economic value of individual mines in the Tarkine for 2013.

$$\mathrm{APV} = (\mathrm{OP}) - ((\mathrm{RL} + \mathrm{RM} + \mathrm{RC} + \mathrm{HPV}) - (\mathrm{FI}))$$

where APV = adjusted present mineral deposit value, OP = operating profit of mine, RL = share of rail maintenance and capital replacement costs of the mine at net present value, RM = shared of road maintenance costs of the mine at net present value, RC = share of road capital replacement costs of the mine at net present value, HPV = shared of high productivity vehicle route upgrade costs of the mine at net present value and FI = income from rail freight charges received from the mine at net present value.

The net present value (NPV) was calculated using the following formula (Fisher 1907):

$$NPV = -C_0 + \frac{C_1}{1+r} + \frac{C_2}{(1+r)^2} + \ldots + \frac{C_T}{(1+r)^T}$$

where $-C_0$ = initial investment, C = adjusted mineral deposit value, r = discount rate and T = the time period. Alternative discount rates (7% and 10%) and time scales (4-years and 10-years) were applied to the NPV formula.

The net present value expressed the net value of the mineral deposit over its potential operating life with ore delivered to the Burnie port or Port Latta. It reflected the value of the mineral resource ($) at the present time in the context of ongoing life cycle costs of road and rail infrastructure servicing each mine, and the direct rail freight revenue received by the Tasmanian Government. The adjusted value thus included government subsidisation of mining operations as part of the NPV calculation, rather than just the costs and benefits to the mining companies.

Pre-mining in-ground values were based on mineral commodity prices in October 2011. Where pre-mining in-ground values of mines were not available, surrogate figures were calculated by multiplying modelled deposit types by $/t (Large & McNeil 2012) by ore reserve quantity (t), either measured or inferred (MRT 2011).

Net present values and operating profits were sourced from mining company ASX registered reports or independent investment assessments. Mines that were in mineral exploration / prospect evaluation phase (Long Plains and Mt Charter) had not advanced to NPV assessment stage. In these cases, potential NPV values were calculated by applying the percentage difference between NPV and pre-mining in-ground values of existing commensurate mines (Savage River, Que River, Fossey and Hellyer). These figures may have less than 10% reliability given that the predicted ore reserves are inferred (Baurens 2010).

NPV values for other deposits (Corinna, Hawes Creek & Blackwater, Mt Bischoff, Burns Peak and South Hercules) were calculated by estimating discounted cash flows over the expected mine life at a rate of 10%. For these mines, expected annual revenues and profit margins were sourced from ASX registered reports and independent investments assessments for each mine proposal. These estimated NPV values and operating profits were calculated using inputs such as expected mine operation costs (including taxes and royalties), projected annual ore extraction and mineral recovery rates and current market prices.

The Melba rail line is exclusively used for transportation of mineral ores from the west coast of Tasmania. Rail maintenance and capital costs were attributed to each mine according to their percentage of total annual freight weight. Rail maintenance and capital replacement costs were calculated over 4- and 10-year periods at discount rates of 7% and 10% per annum. Rail bulk freight charges of 6.75c per net tonne kilometre (Otway & Ferreira 1992; Australian Government 2013b) at discount rates of 7% and 10% p.a. were subtracted from the total rail costs of each mine. The capital upgrade of the Melba line proposed by the Tasmanian Government (2012d) of $37,000,000 and $118,000,000 to $132,000,000 (SKM 2012) was not factored into rail costs. This cost reflected the long periods of underinvestment and poor asset condition (SKM 2012). It is assumed that the estimated capital replacement cost provided in this assessment would replace the Melba line in its current format, in the absence of any major alignment or track gauge upgrades.

While mineral royalties were assumed to be included in net present value, they are reported in the present study as a comparator with infrastructure subsidisation. Mineral royalty incomes is reported by the Tasmanian Government as a total sum. Some mining companies such as Grange Resources Limited publish the royalties paid in annual reports. For other mines where mining royalties were not reported, royalties were calculated using the following formula (Australasian Legal Information Institute 2014):

$$R = (0.019 \text{ x } N) + (0.4 \text{ x } p^2) / N$$

where R is the royalty, N is the mineral yearly net sales and p is the yearly profit. Yearly net sales and profits were calculated using April 2014 mineral market prices and ore deposit reserve size and assay data. For deposits that were prospective (Long Plains and Mt Charter), potential yearly ore extraction tonnage and costs were calculated by using rates from commensurate deposit models of similar size and scale (such as Savage River and Hellyer, Que River and Fossey). Discount rates of 7 and 10% p.a. were applied to the potential royalty for each deposit over the expected mine life. The following royalty was applied to metallurgical silica mines (Corinna, Hawes Creek and Blackwater) of $1.20 per tonnes or 5% of value; whichever was greater (Tasmanian Government 2013). Discount rates of 7% and 10% p.a. over the expected life were applied to these mines.

The Tasmanian Government carries out preventative maintenance of roads at 13-year intervals in order to maximise net present value of road assets (Roper, Michel & Nichols 2008). Capital funding for road reconstruction is triggered by surface roughness within a condition analysis period of 15 years with a discount rate of 7% p.a. The asset lifecycle of sealed roads in Tasmania is expected to be between 30 and 40 years where routine maintenance is provided (Roper, Michel & Nichols 2008).

Road maintenance costs were ascribed to mines pro rata corresponding with maintenance 13-year period cycles (Roper, Michel & Nichols 2008). Capital replacement costs and HPV capital upgrades were ascribed to mines pro rata corresponding with total 30-year lifecycle costs and financing strategies (Roper, Michel & Nichols 2008). Thus, maintenance and capital funding of road assets were attributed to the mines according to 4-year and 10-year development time frame options and 7% and 10% discount rate p.a. variables.

Amortisation of road infrastructure costs is based on axle load (Hore-Lacy, Thoresen & Martin 2012; Martin 2000). Road maintenance costs for sealed roads were calculated by determining the percentage of wear and tear imposed by each mine operation based on AADTT (annual average daily truck traffic) movements (Hore-Lacy, Thoresen & Martin 2012; Martin 2000). The annual pavement maintenance cost (*me*) was determined by:

$$me = a + 0.00309 \times \text{ESA/lane/year}$$

where a = routine maintenance cost (increased with traffic load range), ESA/lane/year = equivalent standard axle per lane per year. Where MESA was >0.1, 76% of the cost was attributed to truck traffic (*b*) and where MESA was <0.1 50% of the cost was attributed to truck traffic (*c*) (Martin 2000). The total freight mass (KT/yr) for each road segment (SKM 2012) was analysed to determine the amount each mine contributed toward total truck traffic (*b*,*c*) on specific routes. Additional AADTT movements were added for proposed mines.

Where AADTT movement data were not available (Pieman, Takone, Temma, Rebecca and Roger River roads) freight mass for each road segment was calculated by using intra-regional freight task data (Tasmanian Government 2013d). Maintenance costs for gravel roads were calculated by applying cost adjustment factors based on traffic volume as per Jahren et. al. (2005). Capital replacement costs of roads were calculated by determining the percentage each mine contributed toward the total road traffic (AADT and AADTT) for each road segment.

Some existing roads within the study area servicing mines did not meet the full requirements of Tasmanian HPV (high productivity vehicle) guidelines (SKM 2012). Capital upgrade estimates (SKM 2012) were included for relevant routes (Pieman Road and Murchison Highway) at P90 projections (90% probability that project costs will not exceed estimates) (Tan & Makwasha 2010). The mines that would utilise the HPV upgraded roads would be responsible for 99% of expected total freight volume on the Pieman Road and 47% of expected total freight volume on the Murchison Highway. The costs of the road upgrades were shared between mines based upon their percentage contribution toward overall heavy freight traffic (Table 3-5).

Standard transport infrastructure valuation methods (Dowling 2000; ECORYS Transport & CE Delft 2005; Eberts 2014) were used in the following equation to quantify the present value (fixed cost) of the transport infrastructure supporting development resources:

$$PV = (CR \times SU) + (M \times SU)$$

where PV = present value of transport infrastructure (road or rail), CR = annual contribution to capital replacement cost, SU = share of use of transport segment incurred by the development resource (such as minerals, wood, tourism or carbon), M = annual maintenance cost. The net present value (NPV) was calculated using the following formula (Fisher 1907):

$$NPV = -C_0 + \frac{C_1}{1+r} + \frac{C_2}{(1+r)^2} + \ldots + \frac{C_T}{(1+r)^T}$$

where $-C_0$ = initial investment, C = present annual capital and maintenance value of transport infrastructure, r = discount rate and T = the time period. Alternative discount rates (7% and 10%) and time scales (4-years and 10-years) were applied to the NPV formula.

3.3.4 Identifying economic value of prospective mineral areas

The economic value of prospective mineral areas were determined by 1) determining total transport costs of ore to the Burnie Port and 2) predicting potential NPV of the mineral prospectivity mapping layer in GIS. Prospective mineral areas were given adjusted values using the same method as existing mines, by subtracting net transport infrastructure provision costs from NPVs.

Existing mines were assessed for proximity to major road and rail transport infrastructure (Melba rail line, the Savage River Pipeline and highways, major arterial roads, arterial roads and access roads from the List transport segments layer). The top 11 ranked mines had a mean distance of 2.98 km to major transport infrastructure, with eight mines being located within 3 km of rail line and roads. The three mines that were not located within 3 km of transport infrastructure (Long Plains, Corinna and Hawes Creek & Blackwater) had a less reliable adjusted value ranking due to their prospective NPV. These mines were excluded from the adjusted value calculations for potential new mining areas described in this section of the chapter. The bottom seven ranked deposits had a mean distance of 8.73 km to transport infrastructure and a maximum distance of 15.8 km.

Four buffer areas were created in GIS with distances of <2.98 km, 2.98 to 8.73 km, 8.73 to 15.8 km and >15.8 km from major road and rail transport infrastructure. Transport costs were calculated by estimating the mean total transport costs for mines located within each buffer area. Additional buffers at 7 km intervals were added to the 15.8 km buffer to allow for costs for remote roads. For prospective mining areas located beyond 15.8 km from existing transport infrastructure, an average cost per km from the mine to the Burnie port was calculated from the most remote mines located in the 8.73 km to 15.8 km buffer. Some of the new mining areas required new roads to access the resource. Buffers were applied to existing remote roads at 7 km intervals allowing for new roads at HPV standard.

Prospective mining areas were identified by applying weightings to polygons of known mineral deposits, potential mineral deposits, areas with geological potential for mineral deposits and potential reworking of past deposits (Table 3-6). Buffers were applied to polygons that related to deposits (Table 3-6).

Table 3-5 – Value of the existing mineral resource

Mine life (yr)	**Existing and proposed deposits**	**Operating profit p.a. ($)**	**Net rail cost p.a. ($)**	**Road maintenance cost p.a. ($)**	**Road capital replacement cost p.a. ($)**	**HPV cost p.a. ($)**	**Total costs p.a. ($)**	**Adjusted mineral deposit value ($)**	**Royalty p.a. ($)**	**Mine area (ha)**
10	Rosebery[i]	**54,000,000**	**49,815**	0	0	0	49,815	**53,950,185**	5,970,000	144.40
17	Savage River[i]	28,997,932	0	303,650	84,850	0	388,500	28,609,432	8,500,000	**1,267.07**
9	Mt Lindsay[ii]	23,560,000	0	568,284	514,150	2,744,985	3,827,419	19,732,581	**12,804,721**	234.77
10	Mt Cleveland[ii]	16,380,000	0	90,726	83,202	0	173,928	16,206,072	4,000,000	77.55
15	Hawes Ck & Blackwater[i]	16,170,000	0	629,006	318,499	0	947,505	15,222,495	*18,000*	29.65
15	Corinna[i]	16,170,000	0	888,637	69,897	0	958,534	15,211,466	*18,000*	42.81
5	Renison[i]	15,059,565	24,907	0	0	0	24,907	15,034,658	4,477,500	212.11
16	Long Plains[ii]	9,694,080	0	412,964	115,396	0	528,360	9,165,720	2,183,777	42.78
10	Riley Creek[ii]	10,491,500	0	529,642	423,194	1,143,778	2,096,614	8,394,886	2,082,048	106.38
4	Que River, Fossey[i]	8,250,580	33,210	0	0	0	33,210	8,217,370	1,720,000	45.90
10	Mt Livingstone[ii]	10,491,500	0	615,843	511,401	**4,103,359**	**5,230,603**	5,260,897	2,082,048	88.58
4	Mt Bischoff[i]	4,823,390	0	24,124	4,060	0	28,184	4,795,206	3,994,587	7.93
4	Hellyer[i]	4,327,227	16,605	0	0	0	16,605	4,310,622	860,000	136.96

Mine life (yr)	**Existing and proposed deposits**	**Operating profit p.a. ($)**	**Net rail cost p.a. ($)**	**Road maintenance cost p.a. ($)**	**Road capital replacement cost p.a. ($)**	**HPV cost p.a. ($)**	**Total costs p.a. ($)**	**Adjusted mineral deposit value ($)**	**Royalty p.a. ($)**	**Mine area (ha)**
17	Arthur Lyons[ii]	5,599,999	0	528,168	**1,232,992**	0	1,761,160	3,838,839	300,000	57.58
10	Mt Charter[ii]	1,596,909	12,454	0	0	0	*12,454*	1,584,455	898,700	4.42
1	Burns Peak[i]	1,964,700	0	89,209	218,605	1,318,892	1,626,707	337,993	451,881	*3.54*
1	South Hercules[i]	209,077	0	63,225	158,839	0	222,064	-12,987	48,088	66.43
10	Nelson Bay[i]	*-3,215,840*	0	**1,107,010**	403,300	0	1,510,310	*-4,726,150*	977,333	143.98
	Totals	**224,570,619**	*136,990*	5,850,489	4,138,386	9,311,014	19,436,878	205,133,741	51,386,683	2,712.84
9.33	Mean	**12,476,146**	*7,611*	325,027	229,910	517,279	1,079,827	11,396,319	2,854,816	150.71

NPV 10-4	*697,251,749*	*423,997*	*15,469,184*	*11,172,978*	*26,055,308*	*53,121,467*	*644,130,282*	*143,571,427*
NPV 7-4	754,153,300	458,547	16,627,086	12,019,805	28,070,993	57,176,431	696,976,869	155,150,186
NPV 10-10	1,462,952,693	610,992	28,104,911	20,451,646	48,167,864	97,335,413	1,365,617,280	266,105,871
NPV 7-10	**1,664,672,334**	**694,339**	**32,649,461**	**23,785,357**	**56,110,192**	**113,239,349**	**1,551,432,985**	**307,979,525**

Highest values in bold, lowest in italic, *i* = existing mine, *ii* = proposed mine, NPV = net present value, 7-4 = 7% discount rate p.a. over 4 years, 10-4 = 10% discount rate p.a. over 4 years, 7-10 = 10% discount rate p.a. over 10 years and 10-10 = 10% discount rate p.a. over 10 years. Operating profit p.a. (including taxes and royalties), Net rail cost p.a. (rail bulk freight charges minus rail maintenance and capital replacement costs), HPV cost p.a. (high productivity vehicle route upgrade costs), Adjusted mineral deposit value (operating profit p.a. minus total costs p.a.) and royalty p.a. (reported or expected mining royalty).

Table 3-6 – Criteria for assigning mineral potential weightings in the Tarkine.

Score	Category	Mineral potential relevance	Buffer (m) applied	Data input
10	Known deposits	Ongoing mineral potential	500	Working volcanogenic massive sulphide deposits, world class deposits; VMSD (Moisier, Berger & Singer 2009)
9		Mineral potential demonstrated and being extracted	500	Working deposits (MRT 2013b) and mines under construction (various)
8		Mineral potential demonstrated, extraction halted due to commodity prices	500	Deposits in maintenance mode (various)
7		Mineral potential indentified and preliminary works under way to extract	500	Mines under construction (Venture 2013)
6		Mineral potential indentified and proposals for extraction	500	Proposed mines (various)
5	Potential deposits	Mineral potential identified	500	New modelled and drill tested deposits (Bass Metals 2006; Elementos 2013; Grange 2013b, 2103c)
4		Mineral potential being explored	500	Drill tested exploration target skarns (Venture Minerals 2012)
3	Geological potential	High mineral potential possible	0	High mineral potential (Large & McNeil 2012)
2		Medium mineral potential possible	0	Medium mineral potential (Large & McNeil 2012)
1	Potential reworking of past deposits	Mineral potential demonstrated and extracted in the past, maybe exhausted but may have future potential	500	Abandoned mines and non operating mines (MRT 2013a)

NPVn (new net present values) were applied to the mineral prospectivity layer. NPVs for all known and potential deposits were calibrated to reflect 7% and 10% discount rates p.a. and 4- and 10-year times frame variables. The highest and lowest current NPV for each scenario (7% discount rate p.a. over 4 or 10 years and 10% discount rate p.a. over 4 or 10 years) from existing mines were applied to the maximum (total score 18) and minimum (total score 1) coinciding weighted mineral prospectivity scores generated from (Table 3-5). New NPVs were evenly divided between these score ranges for each scenario.

Total transport costs were subtracted from NPVn of mineral prospectivity to create an adjusted economic value for prospective mineral areas. Each polygon was given a total possible adjusted economic value. This value did not reflect the reality of the possible scale of mining development over temporal scales, as it would assume that all prospective areas could be developed at once (all within the 4 or 10 year development time frame) which would be fanciful. In order to address this problem of temporality, the total possible adjusted economic value for polygons was converted to rates of $/ha. The spatial analysis of existing mines was used to determine the realistic total footprint of mining activity over a 10 year time period, supported by the fact that the mean mine life of existing mines was approximately 9.05 years. The total footprint of existing mines was 2,068 ha, with a mean mine size of 172.38 ha. It was assumed that the working footprint of existing mines therefore represented a realistic level of mineral activity. This approach allowed for the possibility of mineral development in any polygon (where mineral prospectivity was present) using a realistic NPV range, thus creating the broadest extent of prospective mineral development to trade off against other development resources.

The number of potential mines in prospective areas were calculated by dividing the area of each value range by the mean mine size (172 ha). This reflected the realistic number of mines that could be developed at any one period of time (e.g. a mineral prospective polygon of adjusted value of $466 totalling 341 ha, when divided by 172 could on average support 1.98 mines). The total potential adjusted value ($) of prospective mineral areas was calculated by multiplying the number of mines by the adjusted value (e.g. a polygon that was valued as $466 was multiplied by 1.98 to create a new revised value totalling $922). The potential adjusted value ($/ha) for prospective mineral areas was calculated by dividing the total area for that value range by the number of mines it could support (e.g. a polygon that was valued as $466 totalled 341 ha, the new revised value of $922 was divided by 341 to give a rate of $2.13/ha) (Figure 3.3a). The average potential adjusted value for all mineral prospective areas was $502,576, which when multiplied by the expected total area of mines

(2,068 ha) over a 10 year period equated to an adjusted value of $1,039,327,602. This was 2.2% more than the value of existing mines ($1,063,323,116) under the same discount rate and time frame variables.

3.3.5 Prospective mineral area value using industry output multiplier

Alternative NPVs were created for spatial sensitivity analysis by using industry output multipliers. Alternative NPVs were estimated for existing and proposed mines by subtracting roading costs from the total gross output multiplier impact generated from potential gross mining revenues and expenditure (Table 3-7). Standard industry output multiplier valuation methods (Leontief 1966; Drake 1976; Ehrlich, Landefeld & Barker 1997; D'Hernoncourt, Cordier & Hadley 2011; Gretton 2013) were used in the following equation to quantify the potential total gross output multiplier impact value of the prospective mineral resource in the Tarkine for the year 2013.

$$\mathrm{O}i = ((\mathrm{OMULT})j \times \mathrm{GR}j)) + ((\mathrm{OMULT})j \times \mathrm{GE}j))$$

where Oi = output multiplier impact value of the prospective mineral resource, (OMULT)j = direct output multiplier for the mining industry and GRj = the total potential gross revenue of existing or proposed mines owned by Australian companies and GEj = the total potential gross expenditure of existing or proposed mines owned by overseas companies. Potential gross revenue for existing or proposed mines was calculated by the following equation:

$$\mathrm{GR}j = (\mathrm{OTPA} \times \bar{x}\mathrm{P\$/t})\mathrm{m} + (\mathrm{OTPA} \times \bar{x}\mathrm{P\$/t})\mathrm{m} + \ldots.. (\mathrm{OTPA} \times \bar{x}\mathrm{P\$/t})\mathrm{m}$$

where GRj = total potential gross revenue for existing or proposed mines, OTPA = tonnes per annum of ore produced, $\bar{x}$P$/t = mean market price per tonne in 2013 for the specific ore sold and m = existing or proposed mine operation.

Potential gross expenditure for existing or proposed mines was calculated by the following equation:

$$\mathrm{GE}j = (\mathrm{OTPA} \times \mathrm{C\$/t})\mathrm{m} + (\mathrm{OTPA} \times \mathrm{C\$/t})\mathrm{m} + \ldots.. (\mathrm{OTPA} \times \mathrm{C\$/t})\mathrm{m}$$

where GEj = total potential gross expenditure for the prospective mineral resource, OTPA = tonnes per annum of ore produced, C$/t = cost per tonne in 2013 to produce the specific ore sold, m = existing or proposed mine operation.

Standard transport infrastructure valuation methods (Dowling 2000; ECORYS Transport &

CE Delft 2005; Eberts 2014) were used in the following equation to quantify the alternative present value of existing and proposed mines:

$$APV = (Oi) - ((RL + RM + RC + HPV) - (FI))$$

where APV = alternative present value, O*i* = output multiplier impact value of the prospective mineral resource, RL = share of rail maintenance and capital replacement costs of the mine at net present value, RM = shared of road maintenance costs of the mine at net present value, RC = share of road capital replacement costs of the mine at net present value, HPV = share of high productivity vehicle route upgrade costs of the mine at net present value and FI = income from rail freight charges received from the mine at net present value. The alternative net present value (NPV) was calculated using the following formula (Fisher 1907):

$$NPV = -C_0 + \frac{C_1}{1 + r} + \frac{C_2}{(1 + r)^2} + \ldots + \frac{C_T}{(1 + r)^T}$$

where $-C_0$ = initial investment, C = alternative present value of the prospective mineral resource, r = discount rate and T = the time period. Alternative discount rates (7% and 10%) and time scales (4-years and 10-years) were applied to the NPV formula.

Table 3-7 – Alternative economic potential of the prospective mineral resource p.a.

Potential gross revenue (GR*j*) ($/p.a.)	**Output multiplier (OMULT)*j***	**Output multiplier impact (O*i*) ($/p.a.)**	**Road infrastructure costs ($ p/a)**	**Alternative present value (APV) ($/p.a.)**
985,549,011	1.7	1,675,433,319	19,436,878	1,655,996,441
	Alternative Net present value ($)			
	10-4	**7-4**	**10-10**	**7-10**
	5,185,633,656	5,608,193,044	9,821,212,585	11,486,207,274

7-4 = 7% discount rate p.a. over 4 years, 10-4 = 10% discount rate p.a. over 4 years, 7-10 = 10% discount rate p.a. over 10 years and 10-10 = 10% discount rate p.a. over 10 years.

Of the 18 existing and potential mines in the Tarkine in 2013, overseas companies owned three. Approximately 84% ($536,462,772) of the total estimated gross revenues of operating mines in 2013 were returned to overseas companies, therefore creating revenue leakage outside the Tarkine. Reliable profit-based data for the mineral industry in Tasmania were unavailable and revenue-raising proxies such as value of production have been argued as more appropriate for resource valuation (Tasmanian Government 2007). Potential gross expenditure (including ore transport costs) were used to reflect a realistic level of economic contribution these mines made to the regional economy, totaling $218,814,773 (22% of total adjusted revenue and expenditure of existing and proposed mines in the Tarkine for 2013).

The same method that was used to identify potential adjusted values ($/ha) for prospective mineral areas (*2.4 Identifying economic value of prospective mineral areas*) was used to quantify ($/ha) values for the alternative prospective mineral resource using the output multiplier.

3.3.6 Valuing the wood resource

Vegetation communities dominated by Tasmanian native species used for timber products were exported from TasVeg 2.0. They were those dominated by *Eucalyptus obliqua*, *E. delegatensis*, *E. regnans* and *Acacia melanoxylon.* These polygons were intersected with the tall native eucalypt polygons from the Forest Groups layer to identify tall forest types. The Deep Red Myrtle (DRM, tall *Nothofagus cunninghamii*) resource layer was added to create the potential forest resource layer.

The following system was used to map and quantify the potential sustainable yield of native forest in 2013 based on principles of wood removal commensurate with incremental growth / forest productivity. Sustainable harvest yields were determined by average wood yields per hectare per unit time for each forest type (Whiteley 1999). Average rotation length (years) was applied following Whiteley (1999).

The biological production function model was used to determine potential sustainable economic value of native forest. It describes the growth of the volume of timber over time per hectare combined with product value (Campbell 1999). The following equation was applied to determine the potential sustainable economic values:

$$V = (\text{SGMt/ha/year} \times \text{MDLV/m}^3) \times \text{ha}$$

where V is the sustainable economic value ($), SGMt is the sustainable harvest of green metric tonnes according to forest type per hectare, MDLV is the mill door landed value (estimated market value of logs at the mill door or at the wharf after costs) of the timber per cubic metre according to each species. Green weight value (GWV) is the estimated market value of the green timber per cubic metre before input costs (harvesting, stumpage and haulage) according to each species (Table 3-8).

Table 3-8 – Potential sustainable economic value inputs

Forest resource	SGMt/ha/year	MDLV/m^3 ($)	GWV/m^3 ($)
Tall *Eucalyptus obliqua* forest	3	62.96	159.70
Deep Red Myrtle resource Tall *Nothofagus cunninghamii*	0.44	103.00	276.00*
Tall *Acacia melanoxylon* forest	1.5	124.00	276.00

*Market value figures for the tall *Nothofagus cunninghamii* resource other than MDLV($/m^3) could not be found. Tall *Acacia melanoxylon* resource market values were used for the tall *Nothofagus cunninghamii* resource at $276/m^3, reflective of the average GWV($/m^3) price of speciality timbers.

Sustainable profitability of the resource per hectare was calculated by determining fixed costs, variable transport costs and infrastructure amortisation (Table 3-2). The economic valuing of wood resources was calculated using biological production function modeling (Campbell 1999) and sustainable harvest rates (SGMt/ha/year) (Whiteley 1999). The economic return figure reflects the value of the resource ($) per ha in any given year where sustainable wood extractions rates and ongoing life cycle costs of road infrastructure are applied, given the continuous sustainable rotation production mode selected.

Standard wood resource (Campbell 1999) and transport infrastructure valuation methods (Dowling 2000; ECORYS Transport & CE Delft 2005; Eberts 2014) were used in the following equation to quantify the present value of wood resources in the Tarkine per hectare:

$$PV = (SGMt/ha/year \times GWV/m^3) – (RM/ha + RC/ha + HC/ha + SC/ha + HLC/ha)$$

where PV = present value of wood resource, i.e. gross profit (present value of cash inflows net of present value of the gross profit realised per hectare at the time of sale in 2013), SGMt = sustainable harvest of green metric tonnes according to forest type, GWV = estimated market value of the green timber per cubic metre before input costs, RM = share of road maintenance costs of the wood resource at net present value, RC = share of road capital replacement costs of the wood resource at net present value, HC = harvest costs at net present value, SC = stumpage costs at net present value and HLC = haulage costs to the Burnie port at net present value. An example of how the equation was applied is shown in

Table 3-9.

The net present value (NPV) was calculated using the following formula (Fisher 1907):

$$NPV = -C_0 + \frac{C_1}{1+r} + \frac{C_2}{(1+r)^2} + \ldots + \frac{C_T}{(1+r)^T}$$

where $-C_0$ = initial investment, C = present value of the wood resource, r = discount rate and T = the time period. Alternative discount rates (7% and 10%) and time scales (4-years and 10-years) were applied to the NPV formula (Table 3-10).

Table 3-9 – Example of valuing of the wood resource ($/ha)

Fixed WRP values per ha /year	$/ha
<u>Market value of resource:</u>	
Tall WO codes (*Eucalyptus obliqua*)	566.64
DRM (tall *Nothofagus cunninghamii)*	121.44
Tall NAF NAR (blackwood, *Acacia melanoxylon*)	414.00
<u>Road infrastructure:</u>	
Additional capital and maintenance costs for new road for remote coupe access	116.38
Maintenance WRP & access roads	19.76
Capital costs of above	10.15
Capital contribution to existing roads	34.96
Maintenance existing roads	17.62
<u>Harvest costs:</u>	
Harvest cost	19.45
<u>Stumpage:</u>	
Tall WO codes (*Eucalyptus obliqua*)/ ha	164.25
DRM (tall *Nothofagus cunninghamii)*/ ha	21.96
Tall NAF NAR (blackwood, *Acacia melanoxylon*) /ha	146.25

<u>Haulage: (*example 120km)*</u>

Tall WO codes (*Eucalyptus obliqua*)/ ha	0.33
DRM (tall *Nothofagus cunninghamii)*/ ha	0.05
Tall NAF NAR (blackwood, *Acacia melanoxylon*) /ha	0.17

Return	$/ha
Tall WO codes (*Eucalyptus obliqua*)/ ha	300.1
DRM (tall *Nothofagus cunninghamii)*/ ha	-2.51
Tall NAF NAR (blackwood, *Acacia melanoxylon*) /ha	165.64

Table 3-10 – Example of NPV of the wood resource ($/ha)

	Net present value ($/ha)			
Wood resource	**10-4**	**7-4**	**10-10**	**7-10**
Tall WO codes (*Eucalyptus obliqua*)/ ha	928.84	1,004.53	1,759.15	2,057.38
DRM (tall *Nothofagus cunninghamii)*/ ha	-7.77	-8.40	-14.71	-17.21
Tall NAF NAR (blackwood, *Acacia melanoxylon*) /ha	512.67	554.46	970.96	1,135.56

7-4 = 7% discount rate p.a. over 4 years, 10-4 = 10% discount rate p.a. over 4 years, 7-10 = 10% discount rate p.a. over 10 years and 10-10 = 10% discount rate p.a. over 10 years.

Potential sustainable wood resource polygons (WRP) were identified from the potential forest resource layer. Stream side areas were removed by applying a 40 m buffer to all existing water bodies, to reflect environmental criticisms of the current forest practices code (McIntosh & Laffan 2005).

Existing road infrastructure suitable for log haulage were selected from the LIST transport segments layer. The existing national/State Highways, major arterial roads, feeder roads, arterial roads and access roads were considered appropriate standard for log truck haulage. Vehicular tracks and four-wheel drive tracks were considered inappropriate for log truck haulage and consequently excluded.

An allocation for roading distance inside the potential WRPs was determined by analysing existing roading patterns of hardwood, softwood plantations within the study area from the 'Forest Group' layer and coupes identified in the DRM project[6] (Mesibov 2002). Roads suitable for haulage were clipped to the existing plantation coupe polygons. Roads inside existing coupe polygons averaged 0.02 km for all three coupe types. This was used to calculate the fixed costs for WRP roading.

It was assumed that the resource would be developed progressively, that is new roads would provide access to more remote areas as the resource was developed. Spatial analysis of the WRPs indicated that 120,981 ha (94%) were within 5 km of existing road networks (with a mean distance to existing roads of 0.53 km) allowing progressive road development. Those that were beyond 5km (7,640 ha) had a mean distance to existing roads of 7.3 km and were allocated a remoting factor to express the additional cost to provide new roads to isolated WRPs. Eight block areas of such WRPs were identified. A new roading allocation of 5km was applied per block to provide access to the nearest edge of WRPs and a $ allocation per hectare was given to cover the cost of the new access roads. These WRPs were more dispersed (mean distance between WRPs 0.18 km compared to 0.015 km of those closer than 5 km to existing roads) by a factor 1.2. Maintenance and capital costs were increased by this factor to reflect higher roading impost.

Capital and maintenance costs for existing and new roads were ascribed pro rata consistent with the approach used for the mineral resource, with an exception that an allocation of 18% of these costs was attributed to the wood resource, reflecting the percentage of freight trips in Tasmania involving the transport of logs (Tasmanian Government 2008) rather than applying AADTT axle loadings.

Haulage costs were derived by calculating the distance of the wood resource to the Burnie Port via the major road system. Highways, major arterial roads, arterial roads and feeder roads were extracted from the List transport segments layer. Furthest distance from each of these road segments to the Burnie Port was calculated. These distances were analysed for differences with 'near tool' for existing coupes to the port (straight line). A distance factor of 0.18 was applied to reflect the additional haulage distance required to equal the true haulage distance by existing roads. The sustainable economic value of the wood resource was mapped using the $/ha NPVs (Figure 3.3b).

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6 The DRM project identified the Deep Red Myrtle (tall *Nothofagus cunninghamii*) resources in Tasmania.

Alternative NPVs were estimated by subtracting roading costs from the total gross output multiplier impact generated from potential gross wood revenues (Table 3-11). Standard industry output multiplier valuation methods (Leontief 1966; Drake 1976; Ehrlich, Landefeld & Barker 1997; D'Hernoncourt, Cordier & Hadley 2011; Gretton 2013) were used in the following equation to quantify the potential total gross output multiplier impact value of the wood resource in the Tarkine per hectare.

$$\mathrm{O}i = (\mathrm{OMULT})j \times \mathrm{GR}j$$

where O*i* = output multiplier impact value of the wood resource, (OMULT)*j* = direct output multiplier for the wood industry and GR*j* = the potential gross revenue of the wood resource. Potential gross revenue for the wood resource was calculated by the following equation:

$$\mathrm{GR}j = (\mathrm{SGMt/ha/year} \times \mathrm{GWV/m^3})$$

where GR*j* = potential gross revenue for the wood resource, SGMt = sustainable harvest of green metric tonnes according to forest type, GWV = estimated market value of the green timber per cubic metre. Standard transport infrastructure valuation methods (Dowling 2000; ECORYS Transport & CE Delft 2005; Eberts 2014) and wood resource valuation methods (Campbell 1999) were used in the following equation to quantify the alternative present value of the wood resource in the Tarkine:

$$\mathrm{APV} = (\mathrm{O}i) - (\mathrm{RM/ha} + \mathrm{RC/ha} + \mathrm{HC/ha} + \mathrm{SC/ha} + \mathrm{HLC/ha})$$

where APV = alternative present value, O*i* = output multiplier impact value of the wood resource, RM = share of road maintenance costs of the wood resource at net present value, RC = share of road capital replacement costs of the wood resource at net present value, HC = harvest costs at net present value, SC = stumpage costs at net present value and HLC = haulage costs to the Burnie port at net present value.

The alternative net present value (NPV) was calculated using the following formula (Fisher 1907):

$$NPV = -C_0 + \frac{C_1}{1+r} + \frac{C_2}{(1+r)^2} + \ldots + \frac{C_T}{(1+r)^T}$$

where $-C_0$ = initial investment, C = alternative present value of the wood resource, r = discount rate and T = the time period. Alternative discount rates (7% and 10%) and time scales (4-years and 10-years) were applied to the NPV formula.

Table 3-11 – Alternative economic potential of wood resource p.a.

Potential gross revenue (GR*j*) ($/p.a.)	**Output multiplier (OMULT)*j***	**Output multiplier impact (O*i*) ($/p.a.)**	**Road infrastructure costs ($ p.a.)**	**Alternative present value (APV) ($/p.a.)**
54,270,000	1.88	102,027,600	28,496,000	73,531,600
	Alternative Net present value ($)			
	10-4	**7-4**	**10-10**	**7-10**
	227,587,655	246,232,987	431,034,447	504,107,916

7-4 = 7% discount rate p.a. over 4 years, 10-4 = 10% discount rate p.a. over 4 years, 7-10 = 10% discount rate p.a. over 10 years and 10-10 = 10% discount rate p.a. over 10 years.

3.3.7 Valuing the tourism resource

The economic potential of the tourism resource in the Tarkine was calculated by estimating the Net Present Value (NPV) of tourism by subtracting roading costs from potential tourism revenue profits (Table 3-13).

Standard potential tourism revenue profit valuation methods (Humke, Hilbruner & Hawkins 2015) and transport infrastructure valuation methods (Dowling 2000; ECORYS Transport & CE Delft 2005; Eberts 2014) were used in the following equation to quantify the present value of the tourism resource in the Tarkine:

$$PV = ((CVN + PVN) \times \bar{x}GOPN) - (RM + RC)$$

where PV = present and potential value of the tourism resource, i.e. gross profit (present value of cash inflows net of present value of the gross profit realised at the time in 2013), CVN = current visitor nights, PVN = potential visitor nights, $\bar{x}$GOPN = mean gross operating profit per visitor night, RM = share of road maintenance costs incurred by visitors at net present value, RC = share of road capital replacement costs incurred by visitors at net present value. An example of how the equation was applied is shown in Table 3-12.

The net present value (NPV) was calculated using the following formula (Fisher 1907) :

$$NPV = -C_0 + \frac{C_1}{1+r} + \frac{C_2}{(1+r)^2} + \ldots + \frac{C_T}{(1+r)^T}$$

where $-C_0$ = initial investment, C = present value of the tourism resource, r = discount rate and T = the time period. Alternative discount rates (7% and 10%) and time scales (4-years and 10-years) were applied to the NPV formula (Table 3-13).

Table 3-12 – Economic potential of tourism resource p.a.

Tourism destination / market	**Base visitor nights p.a.**	**Latent visitor nights p.a.**	**Mean gross operating profit per visit**	**Potential revenue ($ p.a.)**	**Road infrastructure costs ($ p.a.)**
Wynyard	19,741	…	268.48	5,300,108	147,896
Rosebery	7,943	…	238.65	1,895,604	59,490
Corinna	7,187	2,401	131.26	1,258,444	71,807
Rocky Cape	20,014	…	59.66	1,194,090	149,896
Guided tours	576	192	1,016.95	781,417	5,755
Arthur River	5,425	1,812	107.39	777,205	54,202
Tullah	4,428	1,479	101.43	599,129	44,241
Latent old growth rainforest guided tours	.	192	1,016.95	195,653	1,441
Latent old growth rainforest wilderness guided tours	.	96	1,708.48	164,349	720
Waratah	.	1,479	59.66	88,242	11,077
Tarkine Drive	.	1,028	59.66	400,263	50,246
Totals	**65,314**	**8,680**	**-**	**12,254,241**	**596,725**

Table 3-13 – NPV of the tourism resource

	Net present value ($)			
Tourism resource	**10-4**	**7-4**	**10-10**	**7-10**
Wynyard	15,946,611	17,246,045	30,201,720	35,321,832
Rosebery	5,682,956	6,146,040	10,763,105	12,587,779
Corinna	3,672,760	3,972,040	6,955,940	8,135,184
Rocky Cape	3,231,884	3,495,239	6,120,954	7,158,642
Guided tours	2,400,751	2,596,380	4,546,848	5,317,667
Arthur River	2,237,766	2,420,114	4,238,166	4,956,665
Tullah	1,717,433	1,857,381	3,252,694	3,804,125
Latent old growth rainforest guided tours	601,105	650,087	1,138,450	1,331,452
Latent old growth rainforest wilderness guided tours	506,448	547,716	959,175	1,121,785
Waratah	238,833	258,295	452,333	529,017
Tarkine Drive	1,083,337	1,171,615	2,051,762	2,399,598
Totals	**37,319,884**	**40,360,952**	**70,681,147**	**82,663,746**

7-4 = 7% discount rate p.a. over 4 years, 10-4 = 10% discount rate p.a. over 4 years, 7-10 = 10% discount rate p.a. over 10 years and 10-10 = 10% discount rate p.a. over 10 years.

The value of the tourism resource by $/ha was calculated by dividing the total NPV value of each destination by the total area (ha) of that destination (e.g. the total NPV value of Wynyard was $35,321,832, this figure was divided by the total footprint of the Wynyard destination (1,769 ha) to provide a $/ha rate of 19,967) (Figure 3.3c).

The valuation was based on the direct economic contribution of tourism generated by the increase in tourism industry sector as a result of visitation (Kookana & Duc Pham 2013) using yield as a measure of profit (Dwyer et al. 2006). Latent demand for visitation in the Tarkine has been estimated at approximately 8,680 overnight stays per annum (EMDA, Moore Consulting & SCA Marketing 2007b) under a scenario where there has not been any additional development or investment in tourism infrastructure. Potential net tourism revenue was calculated by multiplying total potential visitor nights and expected gross profits per average visitor night spend for each relevant destination and market. Total potential visitor nights were based on the 2013 season TVS data (TV Analyser Tourism Tasmania 2014) and latent demand and growth (EMDA, Moore Consulting & SCA Marketing 2007b). Potential net tourism revenue was calculated by 1) identifying industries receiving revenue from direct visitor expenditure (i.e. accommodation, transport and retail) in the North West of Tasmania and 2) determining the expected average gross operating profit margin for each industry.

Tourism polygons were created for specific destinations where TVS data were available. The size of the polygons was determined by the probable areas able to be visited according to the average number of nights stayed for each destination. Other tourism polygons were created for areas with potential appeal to the nature enthusiast market segment. These included areas where existing businesses operate guided tours and areas where future tourism experiences may be attractive to the target market. Old growth rainforest and wilderness polygons were used for areas of latent demand, as these provide core appeal for the key market segment of the Tarkine (Inches 2010; Fry 2014).

Costs for roads were attributed by firstly identifying the total AADT generated by the total potential visitor nights within the main road network. The percentage share of the total AADT that tourism activity would incur on the major road network was calculated at 1.57%. Road costs were shared at this rate for all polygons as tourists are likely to arrive and depart from destinations in the Tarkine randomly. The share of 1.57% was applied to road capital replacement and maintenance costs and calculated at 7% and 10% discount rates p.a. and over 4-year and 10-year time scales.

Secondly, road networks within each polygon were analysed for specific share of tourism use based on percentage of AADT. Capital replacement and maintenance costs at 7% and 10% discount rates p.a. and over 4-year and 10-year time scales were attributed to each tourism polygon according to varying use rates.

Alternative NPVs were estimated by subtracting roading costs from the total gross output multiplier impact generated from potential gross tourism revenues (Table 3-14). Standard industry output multiplier valuation methods (Leontief 1966; Drake 1976; Ehrlich, Landefeld & Barker 1997; D'Hernoncourt, Cordier & Hadley 2011; Gretton 2013) were used in the following equation to quantify the potential total gross output multiplier impact value of the tourism resource in the Tarkine:

$$\mathrm{O}i = (\mathrm{OMULT})j \times \mathrm{GR}j$$

where Oi = output multiplier impact value of the tourism resource, (OMULT)j = direct output multiplier for the tourism industry and GRj = the potential gross revenue of the tourism resource. Potential gross revenue for the tourism resource was calculated by the following equation:

$$GRj = ((CVN + PVN) \times \bar{x}GRN)$$

where GRj = potential gross revenue for the tourism resource, CVN = current visitor nights, PVN = potential visitor nights and $\bar{x}$GRN = mean gross revenue per visitor night.

Standard transport infrastructure valuation methods (Dowling 2000; ECORYS Transport & CE Delft 2005; Eberts 2014) were used in the following equation to quantify the alternative present value of the tourism resource in the Tarkine:

$$APV = (Oi) - (RM + RC)$$

where APV = alternative present value, Oi = output multiplier impact value of the tourism resource, RM = share of road maintenance costs incurred by visitors at net present value, RC = share of road capital replacement costs incurred by visitors at net present value.

The alternative net present value (NPV) was calculated using the following formula (Fisher 1907):

$$NPV = -C_0 + \frac{C_1}{1 + r} + \frac{C_2}{(1 + r)^2} + \ldots + \frac{C_T}{(1 + r)^T}$$

where $-C_0$ = initial investment, C = alternative present value of the tourism resource, r = discount rate and T = the time period. Alternative discount rates (7% and 10%) and time scales (4-years and 10-years) were applied to the NPV formula.

Table 3-14 – Alternative economic potential of tourism resource p.a.

Potential gross revenue (GR*j*) ($/p.a.)	**Output multiplier (OMULT)*j***	**Output multiplier impact (O*i*) ($/p.a.)**	**Road infrastructure costs ($ p.a.)**	**Alternative present value (APV) ($/p.a.)**
56,801,113	1.87	106,218,081	596,725	105,621,356
	Alternative Net present value ($)			
	10-4	**7-4**	**10-10**	**7-10**
	326,908,658	353,547,316	619,141,197	724,104,489

7-4 = 7% discount rate p.a. over 4 years, 10-4 = 10% discount rate p.a. over 4 years, 7-10 = 10% discount rate p.a. over 10 years and 10-10 = 10% discount rate p.a. over 10 years.

3.3.8 Valuing the carbon resource

The economic potential of the carbon resource was calculated by estimating the net present value of carbon by subtracting roading and other fixed costs associated with the management of the resource from carbon trading revenue. The carbon resource was defined as the annual carbon increment of carbon mass and accumulation rates (excluding agricultural lands) in above and belowground environs, were assumed to be anthropogenically undisturbed and subject to natural conditions (Roxburgh et al. 2006).

Standard carbon resource valation methods (May et al. 2012; May 2016) and transport infrastructure valuation methods (Dowling 2000; ECORYS Transport & CE Delft 2005; Eberts 2014) were used in the following equation to quantify the present value of the carbon resource in the Tarkine per hectare:

PV = (CA x CP) – (RM + RC + FM + AD)

where PV = present value of the carbon resource, i.e. gross profit (present value of cash inflows net of present value of the gross profit realised per hectare at the time of sale in 2013), CA = annual carbon growth (t Co_2/ha), CP = carbon trading price ($/t Co_2), RM = share of road maintenance costs of the carbon resource at net present value, RC = share of road capital replacement costs of the carbon resource at net present value, FM = fire management and forest protection at net present value and AD = administration of carbon trading at net present value. An example of how the equation was applied is shown (Table 3-15 and Table 3-16).

The net present value (NPV) was calculated using the following formula (Fisher 1907):

$$NPV = -C_0 + \frac{C_1}{1+r} + \frac{C_2}{(1+r)^2} + \ldots + \frac{C_T}{(1+r)^T}$$

where $-C_0$ = initial investment, C = present value of the carbon resource, r = discount rate and T = the time period. Alternative discount rates (7% and 10%) and time scales (4-years and 10-years) were applied to the NPV formula (Table 3-17).

Table 3-15 – Fixed costs to establish and maintain carbon resource

Fixed costs per ha /year	**$/ha**
Road infrastructure:	
Maintenance existing access roads	0.38
Capital costs of above	0.24
Fire management:	
Forest protection	4.93
Carbon trading costs:	
Audits	5.25
Technical support	6.00
Administration	3.00
Total	**19.80**

Table 3-16 – economic potential of carbon resource p.a. using a volume weighted average carbon price of $13.95 per carbon credit.

Forest / vegetation type	**Total ($t\ CO_2$/ha)**	**Annual growth ($t\ CO_2$/ha)**	**Potential revenue ($ /ha)**	**NPV value ($ /ha) less fixed costs (year 1)**
Forest				
Tall Native Eucalypt (old growth)	2,268	74.75	1,042.76	1,022.96
Rainforest (old growth)	1,999	78.10	1,089.50	1,069.70
Tall Native Eucalypt	1,628	53.64	748.28	728.48
Rainforest	1,441	56.28	785.11	765.31
Low Native Eucalypt	924	42.15	587.99	568.19
Softwood Plantation	473	12.54	174.93	155.13
Hardwood Plantation	366	11.89	165.87	146.07
Other Native Forest	311	10.25	142.99	123.19
Non Forest				
Low native vegetation (scrub)	*155	*5.12	71.42	51.62
Moorland	150	2.53	35.29	15.49

Other native vegetation	*150	*2.53	20.79	0.99
Native grassland	34	1.49	71.42	51.62
Agricultural lands	133	0.35	4.88	4.88
Mean	772	27.02	389.25	361.82

* Estimate only

Table 3-17 – NPV of the carbon resource

	Net present value ($/ha)			
Carbon resource	**10-4**	**7-4**	**10-10**	**7-10**
Tall Native Eucalypt (old growth)	3,166.16	3,424.16	5,996.48	7,013.07
Rainforest (old growth)	3,310.83	3,580.62	6,270.47	7,333.50
Tall Native Eucalypt	2,254.72	2,438.45	4,270.27	4,994.21
Rainforest	2,368.71	2,561.73	4,486.17	5,246.71
Low Native Eucalypt	1,758.60	1,901.91	3,330.67	3,895.32
Softwood Plantation	480.14	519.27	909.36	1,063.52
Hardwood Plantation	452.10	488.94	856.25	1,001.41
Other Native Forest	381.29	412.35	722.13	844.55
Low native vegetation (scrub)	159.77	172.79	302.59	353.89
Moorland	47.94	51.85	90.80	106.19
Other native vegetation	47.94	51.85	90.80	106.19
Native grassland	3.06	3.31	5.80	6.79
Agricultural lands	15.10	16.33	28.61	33.46

The Tasmanian forest group layer (the LIST 2013) was used to identify forest type classes suitable for carbon sequestering potential. Maximum carbon density (t/ha CO_2e), carbon content (%t/m^3) and turn over of carbon to ground (%/yr) estimates for live vegetation, debris and soil in native forests and plantations were used from May et al. (2012) for each forest group (Table 3-16). These estimates have been criticised as a significant underestimation of the carbon sequestering potential of Tasmanian forests (Dean & Kirkpatrick 2012), particularly the prospective carbon sequestering of mature / old growth Rainforest M+ and Eucalypt in E1 mixed-forest. This deficiency was mitigated by increasing the carbon sequestering figures for old growth forests. Additional field categories of old growth tall eucalypt forest and old growth rainforest were created in the layer to allow for an increase in CO_2 sequestering (Dean & Kirkpatrick 2012). Where old growth forest polygons (Forestry Tasmania 2013b) converged with tall eucalyptus forest and rainforest, carbon density (live vegetation and debris) estimates (May et al. 2012) were increased by 50% to correct underestimations raised by Dean & Kirkpatrick (2012).

The TasVeg 2.0 layer was unioned with the Non-forest group to create additional vegetation categories for non-forested areas. Non-forest vegetation polygons were categorised into moorland, low native vegetation (scrub), native grasslands, other native vegetation and agricultural lands. Where carbon sequestration figures for low native vegetation (scrub) and other native vegetation were unavailable, estimates were extrapolated from moorland and other native forest amounts. Low native vegetation (scrub) was assigned 50% of the carbon mass and accumulation rates of Other Native Forest. Other native vegetation was assigned the same carbon mass and accumulation rates as Moorland vegetation.

A volume weighted average carbon price of $13.95 per carbon credit was used. An approximate proportion of share of use of the roads by the land manager to maintain the forest asset of 0.2% to 1.3% (mean 0.68%) was applied to capital replacement and annual maintenance costs. This was calculated by expected ADDT volume for asset management and surveillance including the peak fire risk season. Roading costs were not applied to agricultural lands. Alternative volume weighted average carbon prices of $5.00 and $20.00 per carbon credit were modelled using the same method used for the $13.95 carbon price to calculate alternative NPVs.

Alternative NPVs were estimated by subtracting roading costs from the total gross output multiplier impact generated from potential gross carbon revenues (Table 3-18). Standard industry output multiplier valuation methods (Leontief 1966; Drake 1976; Ehrlich, Landefeld & Barker 1997; D'Hernoncourt, Cordier & Hadley 2011; Gretton 2013) were used in the following equation to quantify the potential total gross output multiplier impact value of the carbon resource in the Tarkine per hectare:

$$\mathrm{O}i = (\mathrm{OMULT})j \ \ \mathrm{x} \ \ \mathrm{GR}j$$

where O*i* = output multiplier impact value of the carbon resource, (OMULT)*j* = direct output multiplier for the carbon sequestering industry and GR*j* = the potential gross revenue of the carbon resource.

Potential gross revenue for the carbon resource was calculated by the following equation:

$$GRj = (CA \times CP)$$

where GR*j* = potential gross revenue for the carbon resource, CA = annual carbon growth (t Co_2/ha) and CP = carbon trading price ($/t Co_2). Standard transport infrastructure valuation methods (Dowling 2000; ECORYS Transport & CE Delft 2005; Eberts 2014) were used in the following equation to quantify the alternative present value of the carbon resource in the Tarkine:

$$APV = (Oi) - (RM + RC + FM + AD)$$

where APV = alternative present value, O*i* = output multiplier impact value of the carbon resource, RM = share of road maintenance costs of the carbon resource at net present value, RC = share of road capital replacement costs of the carbon resource at net present value, FM = fire management and forest protection at net present value and AD = administration of carbon trading at net present value. The alternative net present value (NPV) was calculated using the following formula (Fisher 1907):

$$NPV = -C_0 + \frac{C_1}{1+r} + \frac{C_2}{(1+r)^2} + \ldots + \frac{C_T}{(1+r)^T}$$

where $-C_0$ = initial investment, C = alternative present value of the carbon resource, r = discount rate and T = the time period. Alternative discount rates (7% and 10%) and time scales (4-years and 10-years) were applied to the NPV formula.

Table 3-18 – Alternative economic potential of carbon resource p.a.

Potential gross revenue (GR*j*) ($/p.a.)	**Output multiplier (OMULT)*j***	**Output multiplier impact (O*i*) ($/p.a.)**	**Road infrastructure costs ($ p.a.)**	**Alternative present value (APV) ($/p.a.)**
429,095,043	0.101	472,433,642	16,740,190	455,693,452
	Alternative Net present value ($)			
	10-4	**7-4**	**10-10**	**7-10**
	1,410,416,803	1,525,346,797	2,671,226,729	3,124,081,026

7-4 = 7% discount rate p.a. over 4 years, 10-4 = 10% discount rate p.a. over 4 years, 7-10 = 10% discount rate p.a. over 10 years and 10-10 = 10% discount rate p.a. over 10 years.

3.3.9 Selection of discount rates and development time frames

The existing and proposed mining operations assessed in the present thesis used discount rates between 8% and 12%, with most using 10%, to evaluate existing NPVs. These rates may be low for the more speculative ventures where a discount rate of 15% may be more appropriate to reflect market uncertainties and risk (Taheri, Irannajad & Ataee-Pour 2009). Similarly, a discount rate of 10% may be too high for established mines, as when mines reach operating phases real discount rates of 5% to 8% are used (Taheri, Irannajad & Ataee-Pour 2009). However, given that the NPV range of the mineral prospectivity were based on NPVs of operating mines, the application of a 7% discount rate reflected an appropriate risk-adjusted approach.

Constant discount rates for forest resource valuations range between 3.5% to 15% (Hepburn & Koundouri 2007; Wu & Zhou 2011; New Forests 2015). Declining discount rates are also used ranging from 3.5% to 1% over periods of 300 years (Hepburn & Koundouri 2007). Forestry Tasmania uses discount rates of 8.5% to 11.1% to value the Tasmanian forest resource (Forestry Tasmania 2012), characteristic of higher discount rates compared to non-institutional investments that use 5% to 6% (New Forests 2015).

Discount rates for tourism valuations vary from 3% to 20% according to the investment risk and level of public interest (Fleischer & Felsenstein 2000; Ahmend, Kieok Chong & Cesar 2004; Taylor & Filipski 2014; Bayliss et al. 2014). Discount rates for forest carbon trading valuation vary from 3% to 50% p.a. dependent upon the nature of risk associated with managing the asset (Valatin 2011), with discount rates of 2% to 5% commonly used (Nambiar & Ferguson 2005; Bowen 2011; Valatin 2011; Renwick et al. 2014; May 2016).

Two discount rates of 7% and 10% p.a. were used for the valuation of mineral, wood, tourism and carbon resources. These rates were considered appropriate to capture the range of discount rates used for all development resources considered in this present thesis and enabled comparisons between resources.

Two time frames (4 years and 10 years) were chosen for valuation of mineral, wood, tourism and carbon resources. The 4-year time frame was chosen to reflect the average funding cycles for road maintenance and capital replacement granted to Local Government (Federal Government Roads to Recovery program, 5 year schedule and State Grants Commission, 3 year schedule) (Tasmanian Audit Office 2015). The 10-year time frame represented a mining development cycle (the average mine life was 10 years) and gave a longer development time for comparing development priorities.

3.3.10 Selection of output multiplier

Type 1 direct output multipliers by industry (Leontief 1966) were used to determine the spatial sensitivity (distribution and convergence) of development resource and development option polygons. Some have cautioned the use of output multipliers (Rama & Lawrence 2009; Denniss 2012; Gretton 2013) as they may fail to capture revenue leakage from local and regional economies (Jacobsen et al. 2003). Despite the economic inaccuracies that output multipliers may create, they were used to test the robustness of the spatial implications of valuing development resources in absence of output multipliers. Output multiplier figures were selected for each development resource according to the relevant industry represented (i.e. mining, wood, tourism and carbon) for the year 2013.

Mineral output multipliers were variable and ranged from 1.6 to 3.5 dependent upon the method and inputs accounted (ABS 1990; Davidson & de Silva 2011; Rayner & Bishop 2013; Kookana, Duc Pham & Quinn 2014). In this analysis an output multiplier factor of 1.7 (Kookana, Duc Pham & Quinn 2014) was used for the mineral resource. Wood output multipliers ranged from 1.2 to 2.3 (Hayter 2001; Felmingham 2002; FIAT 2002). An output multiplier of 1.88 (Felmingham 2002) was used, as it was specific to the North Western Tasmanian region. Tourism output multipliers ranged from 1.2 to 1.9 (Jacobsen et al. 2003; van Leeuwen, Nijkamp & Rietveld 2009; Nichol, Shi & Campi 2013b, 2013b; Kookana, Duc Pham & Quinn 2014). An output multiplier of 1.87 (Kookana, Duc Pham & Quinn 2014) was used for the tourism resource.

The selection of an output multiplier for the carbon resource was difficult to determine. Some have suggested the use of multiplier proxies from general government based emissions programmes for avoided deforestation in carbon trading projects ranging from 0.1 to 3.1 (Hemming, Kell & Mahfouz 2002; Pagiola & Bosquet 2009; Ibarrarán & Boyd 2010) whilst others have found that the carbon value of avoided deforestation can be used as a proxy for regulating ecosystem services at a multiplier value of 10.7 (UNEP 2012). Others have argued that the application of multipliers is not appropriate, as economies of scale for sequestering projects are too variable (Boucher 2008; Olsen & Bishop 2009). As economies of scale may influence the success of avoided deforestation carbon trading initiatives, some suggest a fixed proportion between opportunity costs and implementation costs can be considered as an alternative to using a fixed multiplier, ranging between 5 to 33% (Grieg-Gran 2008; Boucher 2008). A conservative multiplier of 0.101 for the carbon resource after Ibarrarán and Boyd (2010) was selected.

Multiplier effects on transport and construction activities were included in the industry output multipliers that were used for each development resource (Felmingham 2002; Kookana, Duc Pham & Quinn 2014) and therefore it was unnecessary to apply additional multiplier factors to rail and road costs.

3.3.11 Selection and analysis of development priorities

Mineral and wood resources were considered compatible land uses. Where both resources were present, economic benefits could be gained from harvesting forests followed by mining development, then replanting forest. In the case of open cut mining, it was assumed that secondary forest would not be developed. Tourism and carbon trading were considered compatible land uses with concurrent development possible. All development layers were unioned in GIS. The mineral and wood NPVs ($/ha) were summed to create a new value field 'MW' (mineral/wood) and the tourism and carbon NPVs ($/ha) were summed to create a new value field 'TC' (tourism/carbon). The TC NPvs were subtracted from the MW NPVs (where MW NPVs > 0) to identify polygons that gave a greater return from minerals and wood. The MW NPvs (where MW NPVs > 0) were subtracted from the TC NPVs to identify polygons that gave a greater return from tourism and carbon (Table 3-20 and Figure 3.4). This process was replicated for all discount rate and time frame variables. The same procedure was used to map the development priorities that used output multipliers (Figure 3.9).

'Contested areas' were polygons where both mineral plus wood, and tourism plus carbon resources were positive (NPV$/ha >0) and occurred within the same polygons. For example, where mineral and wood resources had a higher summed economic value (NPV$/ha) than tourism and carbon resources, these polygons were named as MW (mineral and wood) development option.

Areas referred to as 'multiplier only' were the additional polygons created when the output multiplier was used for each development resource (i.e. minerals, wood, tourism or carbon). For example, 'multiplier only' polygons for the mineral resource indicated areas where the mineral resource had NPV$/ha that were greater than zero (positive) in contested areas when the output multiplier was used and that were less than zero (negative) when the output multiplier was not used. Areas referred to as 'non-multiplier only' were the polygons created excluding the output multiplier (e.g. multiplier only polygons for the carbon resource indicated areas where the carbon resource had NPV$/ha that were greater than zero (positive) in contested areas excluding the output multiplier and that were less than zero (negative) when the output multiplier was used). Areas that were named ‘common to multiplier and non-multiplier’ were polygons where the use and non-use of output multipliers both resulted in positive NPV$/ha values (Figure 3.10).

Areas that contained multiple development resources where mineral, wood, tourism and carbon resource values (using multipliers and non-multipliers) were positive and occurred in the same polygons were contested and referred to as the ‘Resource concentration index’. The resource concentration index score denoted the total number of development resources that coincided within a polygon (Figure 3.11).

3.4 Results

3.4.1 Development resources

Approximately 262,650 ha (30%) of the Tarkine were identified as prospective for minerals (Figure 3.3a). Highest NPVs were concentrated around existing mines close to existing transport infrastructure and lowest NPVs were associated with areas of mineral potential in remote areas that had no transport infrastructure. The Savage River mine area had the highest value for prospective mineral areas with NPV $/ha ranging from 424,053 to 2,143,996, followed by Rosebery working VHMS (917,607 to 1,608,583), Renison Bell (544,914 to 1,474,730) and Mt Bischoff (61,471 to 1,207,023). Existing mines made up for 1% (2,637 ha) of the total prospective mineral potential area. The average NPV ($) within existing mine polygons ranged from 96,980,194 to 214,811,667 and were between 0.4 to 1.1 of the value of known NPVe (NPV of mines regardless of infrastructure costs) of existing mines.

Remote mineral prospective areas had negative NPVs ranging from -2,352,363 to -2,281 $/ha with the largest concentration on the western side of the Norfolk Range. Total royalties for existing and proposed mines ranged from $143,571,427 to $307,979,525 for all discount rate and time frame variables. Total costs for existing and proposed mines ranged from $53,121,467 to $113,239,349 for all discount rate and time frame variables. Prospective mineral areas with a 7% discount rate p.a. over 10 years had the lowest minimum NPV ($/ha) at -2,352,363, the highest maximum of 2,143,996 and the highest mean of 502,576 (Table 3-19). The prospective mineral area remained constant across all discount rate and time frame variables, with negative NPV polygons representing 61% of the total mineral resource and 18% of the study area. Mean transport costs ranged from $3,342,172 to $7,402,930 for all discount rate and time frame variables. The mineral resource had the highest total costs of all development resources (Figure 3.2). Approximately 58% of polygons with a positive adjusted value were located within 3 km of existing major transport infrastructure.

The potential sustainable harvest yield of forests in the Tarkine was assessed for three forest types (tall *Eucalyptus obliqua* forest, tall *Nothofagus cunninghamii* forest and tall *Acacia melanoxylon* forest), totalling 128,709 ha (15%) of the study area regardless of reserve status (Figure 3.3b). The total NPV ($) of the wood resource ranged from 86,332,836 to 176,818,596 for all discount rates and time frames (Table 3-19). Total discounted costs equated to 102% to 119% of total NPVs and ranged from $88,194,300 to $195,352,769. Approximately 71,122 ha were identified as available for harvest according to current reserve status, equating to 55% of the total wood resource. Approximately 87,481 ha (68%) of the wood resource had positive NPV ranging from 467 to 2,057 $/ha. Tall *Eucalyptus obliqua* forest accounted for 66% of the total forest resource regardless of reserve status and 76% of the available forest resource.

The Deep Red Myrtle resource equated to 32% of the total forest resource regardless of reserve status and 21% of the available forest resource. All of the tall *Nothofagus cunninghamii* forest had negative NPVs whilst all of the tall *Eucalyptus obliqua* and tall *Acacia melanoxylon* resource had positive NPVs. This was due to the low sustainable harvest rates for tall *Nothofagus cunninghamii* forest and higher costs because of the more remote locales. The total NPV ($) ranged from 70,516,534 to 156,190,145 for the total resource available for harvest for all discount rate and time frame variables. Approximately 39% of the wood resource regardless of reserve status was old growth and 12% of the forest resource available for harvest was old growth.

Approximately 243,000 ha (28%) of the Tarkine were identified as important for tourism (Figure 3.3c). Highest NPVs were concentrated at Wynyard, Rosebery, Corinna and Rocky Cape and ranged from 3,231,884 to 35,321,832 for all discount rates and time frames. Waratah, Tarkine Drive, latent old growth rainforest wilderness guided tours and latent old growth rainforest guided tours had the lowest total NPVs ($) for all discount rate and time frame variables ranging from 238,448 to 959,175. All tourism resources had positive NPVs with total road infrastructure costs representing between 7% and 9% of total NPVs. Total potential net revenues ($) ranged from 39,166,807 to 86,754,691 and road costs ($) from 1,846,923 to 4,090,945 for all discount rate and time frame variables. Areas that supported latent old growth rainforest guided tours made up for 67% of the total area of the tourism resource (163,201 ha), followed by latent wilderness old growth rainforest guided tours (8%, 19,758 ha), Tarkine Drive (6.5%, 15,834 ha) and the Tarkine coast (5%, 12,345 ha). Total visitor nights equated to 318,699 over the 4-year time period and 796,744 over the 10-year time period.

The carbon resource had the highest total NPVs and largest area of the development resources, totalling 843,613 ha (99%) of the Tarkine (Figure 3.3d). All carbon resources had positive NPVs. Highest NPVs were concentrated in old growth rainforest (196,246 ha, 23% of the total area of the resource), old growth tall native Eucalypt (42,061 ha, 5%), rainforest (43,176 ha, 5%) and tall native Eucalypt (106,439 ha, 12%). Old growth rainforest represented 50% of total NPV across all discount rate and time variables and tall native Eucalypt 19%. Whilst the total discounted costs of the carbon resource were commensurate with those of the mineral resource, it had the highest benefit-cost ratio (25.75) between discounted total costs and revenues ($) of all development resources across all discount rate and time frame variables (Figure 3.2). Approximately 374,511 ha (44%) of the carbon resource were in the reserve estate. Approximately 62% (122,622 ha) of the highest carbon NPV is contained in within the largest contiguous area of cool temperate rainforest. Alternative carbon price modelling using volume weighted average carbon prices of $5.00 and $20.00 per carbon credit yielded total NPV ranges from 429,120,786 to 4,146,315,014 for all discount rate and time frame variables, thus placing the carbon resource as the most economically valuable resource among those considered in the present research.

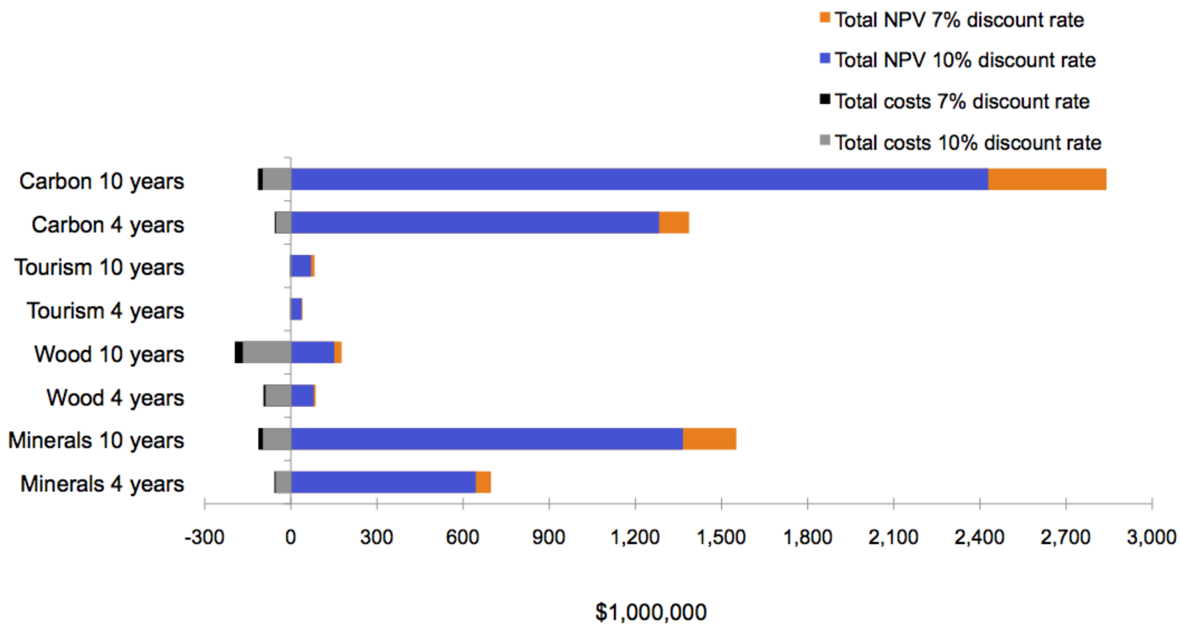

Figure 3.2 – Total NPV and cost comparisons for development resources using variable discount rates and time periods.

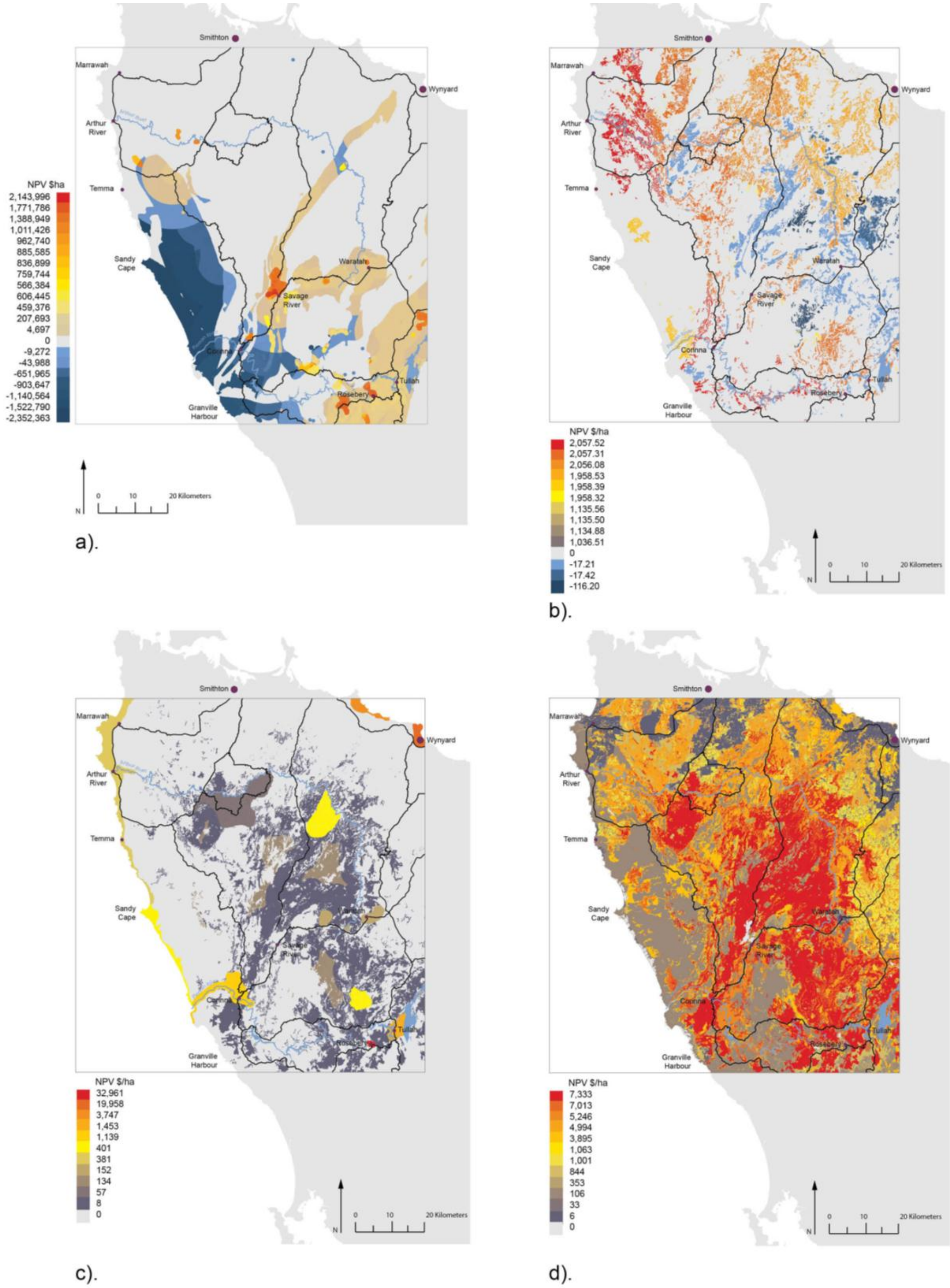

Figure 3.3 – Net present value ($/ha) development resources.

(At 7% discount rate p.a. over 10 years for a) minerals, b) wood, c) tourism and d) carbon excluding output multipliers.)

Table 3-19 – Comparative areas and economic values of minerals, wood, tourism and carbon resources.

Value	**Total area (ha)**	**Total area with +ve NPV*i***	**Total area with +ve NPV[ii]**	**Total area with –ve NPV*i***	**Total area with –ve NPV[ii]**	**NPV $/ha minimum[i]**	**NPV $/ha minimum[ii]**	**NPV $/ha maximum[i]**	**NPV $/ha maximum[ii]**	**NPV $/ha minimum change (%)**	**NPV $/ha maximum change (%)**
Carbon 7-4	**843,613**	**843,613**	**843,613**	*0*	*0*	3.31	3.78	3,580	3,980	*14*	*11*
Carbon 10-4	**843,613**	**843,613**	**843,613**	*0*	*0*	*3.06*	*3.50*	3,310	3,680	*14*	*11*
Carbon 7-10	**843,613**	**843,613**	**843,613**	*0*	*0*	6.79	7.77	7,333	8,151	*14*	*11*
Carbon 10-10	**843,613**	**843,613**	**843,613**	*0*	*0*	5.80	6.63	6,270	6,969	*14*	*11*
Minerals 7-4	262,650	147,971	180,916	**114,685**	**81,741**	-1,160,692	-851,626	1,046,796	5,261,612	26	402
Minerals 10-4	262,650	147,971	180,916	**114,685**	**81,741**	-1,073,238	-787,458	967,926	4,865,178	26	402
Minerals 7-10	262,650	147,971	180,916	**114,685**	**81,741**	**-2,352,363**	**-1,719,360**	**2,143,996**	**10,776,431**	26	402
Minerals 10-10	262,650	147,971	180,916	**114,685**	**81,741**	-2,011,374	-1,470,128	1,833,211	9,214,327	26	402
Tourism 7-4	243,064	243,064	243,064	*0*	*0*	4.27	13	16,093	147,411	204	**815**
Tourism 10-4	243,064	243,064	243,064	*0*	*0*	4.10	13	14,881	136,309	217	**815**
Tourism 7-10	243,064	243,064	243,064	*0*	*0*	8.84	27	32,961	301,922	205	**816**
Tourism 10-10	243,064	243,064	243,064	*0*	*0*	7.94	23	28,183	258,156	189	**816**

Value	**Total area (ha)**	**Total area with +ve NPV*i***	**Total area with +ve NPV*ii***	**Total area with –ve NPV*i***	**Total area with –ve NPV*ii***	**NPV $/ha minimum*i***	**NPV $/ha minimum*ii***	**NPV $/ha maximum*i***	**NPV $/ha maximum*ii***	**NPV $/ha minimum change (%)**	**NPV $/ha maximum change (%)**
Wood 7-4	*128,621*	*87,481*	*127,690*	41,227	*0*	-56.74	764	1,004	3,565	**1,446**	255
Wood 10-4	*128,621*	*87,481*	*127,690*	41,227	*0*	-52.46	706	*928*	*3,297*	**1,445**	255
Wood 7-10	*128,621*	*87,481*	*127,690*	41,227	*0*	-116.20	1,565	2,057	7,303	**1,446**	255
Wood 10-10	*128,621*	*87,481*	*127,690*	41,227	*0*	-99.36	1,338	1,759	6,244	**1,446**	254

Highest values in bold, lowest in italic, *i* = NPV using discounted benefits excluding output multiplier, *ii* = NPV using discounted benefits using output multiplier applied, 7-4 = 7% discount rate p.a. over 4 years, 10-4 = 10% discount rate p.a. over 4 years, 7-10 = 10% discount rate p.a. over 10 years and 10-10 = 10% discount rate p.a. over 10 years. NPV $/ha minimum and maximum change (%) is the percentage increase in the NPV $/ha when output multipliers were applied.

3.4.2 Development priorities

Eight development priorities were assessed involving a) the short and medium term development of minerals and wood resources and b) the short and medium development of tourism and carbon using variable discount rates (7% and 10% p.a.) and time periods (4-years and 10-years) (Table 3-20).

Mineral values dominated the mineral/wood (MW) development priorities (MW 7-4, MW 10-4, MW 7-10, MW 10-10) and made for 100% of the footprint of all MW priorities (Figure 3.4a and Figure 3.4b). Whilst wood values accounted for 6% of the total area of MW development priorities, their NPVs were minute in comparison to mineral resources (0.002% to 0.2% of mineral values $/ha) and their total area was the smallest of all development priorities. The total area of MW development priorities did not vary when alternative discount rate and time frame inputs were applied (Table 3-21). The footprint of high and low range NPVs of mineral areas remained constant in response to applying variable time frames and discount rates.

All MW development priorties were dominated by large areas (73% of the total development footprint, 108,290 ha) of low NPVs with a NPV$/ha value range of 346 to 134,156 (Table 3-21). These areas had geological attributes with possible medium mineral potential. In contrast, an average of 0.33% (483 ha) of total development footprint area had the highest 20% of NPV$/ha values, ranging from 885,598 to 2,143,997. Working deposits and volcanogenic massive sulphide deposits (VMSD) in maintenance mode made up the footprint of these areas. This proportion between areas low and high NPVs did not vary in response to application of alternative discount rates and time frames.

The carbon resource dominated the tourism/carbon map and made up for 100% coverage of all TC priritoes, compared to tourism that had coverage of 41% across all TC development priorities. Areas of high NPV in the tourism/carbon (TC) development priorities (TC 7-4, TC 10-4, TC 7-10, TC 10-10) were concentrated around Wynyard, Corinna, the Meredith Range and the northern end of the Pipeline Plateau (Figure 3.4c and Figure 3.4d). These areas included converging polygons of highest values for the tourism and carbon resources. The footprint of high TC NPV did not vary in response to application of alternative discount rates and time frames, due to the significantly lower NPVs of unviable mineral prospectivity areas. In these areas the negative mineral and wood areas were worth 0.002% of the NPVs of the combined tourism and carbon polygons. The highest 20% of $NPV/ha values for TC development priorities had a value range of 10,336 to 22,896 and represented 0.02% (12 ha) of the total development footprint and was located at Wynyard. In contrast, the lowest 20% of TC NPV$/ha values made up for 79% (57,101 ha) of the total development footprint and had a NPV$/ha value range of 150 to 4,175. Both the MW and TC development priorities had relatively small areas of highest NPV$/ha values compared to low NPV$/ha values.

The TC development priorities had a smaller area than MW development priorities (represented 49% of the total area of MW priorities) and had more variation in total NPV compared to the MW priorities. This was due to the sensitivity of discount rates and time frames when applied to the costs for MW priorities, which reduced total NPVs, particularly MW 10-4. The TC development priorties had greater variation in total NPV due to the low input costs. This made NPVs less sensitive to discount rates and therefore resulted in high NPVs over longer time periods (e.g. TC 10-10 and TC 7-10).

Table 3-20 – Parameters for alternative spatial scenarios for development priorities.

Parameters	**Abbreviation**	**Description**
Short term greater return from minerals and wood resources.	MW 7-4	Polygons where minerals and wood combined have higher value than tourism and carbon combined with a 7% discount rate p.a. over 4 years. Scores indicate the net NPV ($/ha) result if minerals and wood development takes place and losses are incurred from precluding tourism and carbon development.
Short term greater return from tourism and carbon resources.	TC 7-4	Polygons where tourism and carbon combined have higher value than minerals and wood combined with a 7% discount rate p.a. over 4 years. Scores indicate the net NPV ($/ha) result if tourism and carbon development takes place and losses are incurred from precluding mineral and wood development.
Short term greater return from minerals and wood resources.	MW 10-4	Polygons where minerals and wood combined have higher value than tourism and carbon combined with a 10% discount rate p.a. over 4 years. Scores indicate the net NPV ($/ha) result if minerals and wood development takes place and losses are incurred from precluding tourism and carbon development.
Short term greater return from tourism and carbon resources.	TC 10-4	Polygons where tourism and carbon combined have higher value than minerals and wood combined with a 10% discount rate p.a. over 4 years. Scores indicate the net NPV ($/ha) result if tourism and carbon development takes place and losses are incurred from precluding mineral and wood development.
Medium term greater return from minerals and wood resources.	MW 7-10	Polygons where minerals and wood combined have higher value than tourism and carbon combined with a 7% discount rate p.a. over 10 years. Scores indicate the net NPV ($/ha) result if minerals and wood development takes place and losses are incurred from precluding tourism and carbon development.
Medium term greater return from tourism and carbon resources.	TC 7-10	Polygons where tourism and carbon combined have higher value than minerals and wood combined with a 7% discount rate p.a. over 10 years. Scores indicate the net NPV ($/ha) result if tourism and carbon development takes place and losses are incurred from precluding mineral and wood development.
Medium term greater return from minerals and wood resources.	MW 10-10	Polygons where minerals and wood combined have higher value than tourism and carbon combined with a 7% discount rate p.a. over 10 years. Scores indicate the net NPV ($/ha) result if minerals and wood development takes place and losses are incurred from precluding tourism and carbon development.
Medium term greater return from tourism and carbon resources.	TC 10-10	Polygons where tourism and carbon combined have higher value than minerals and wood combined with a 10% discount rate p.a. over 10 years. Scores indicate the net NPV ($/ha) result if tourism and carbon development takes place and losses are incurred from precluding mineral and wood development.

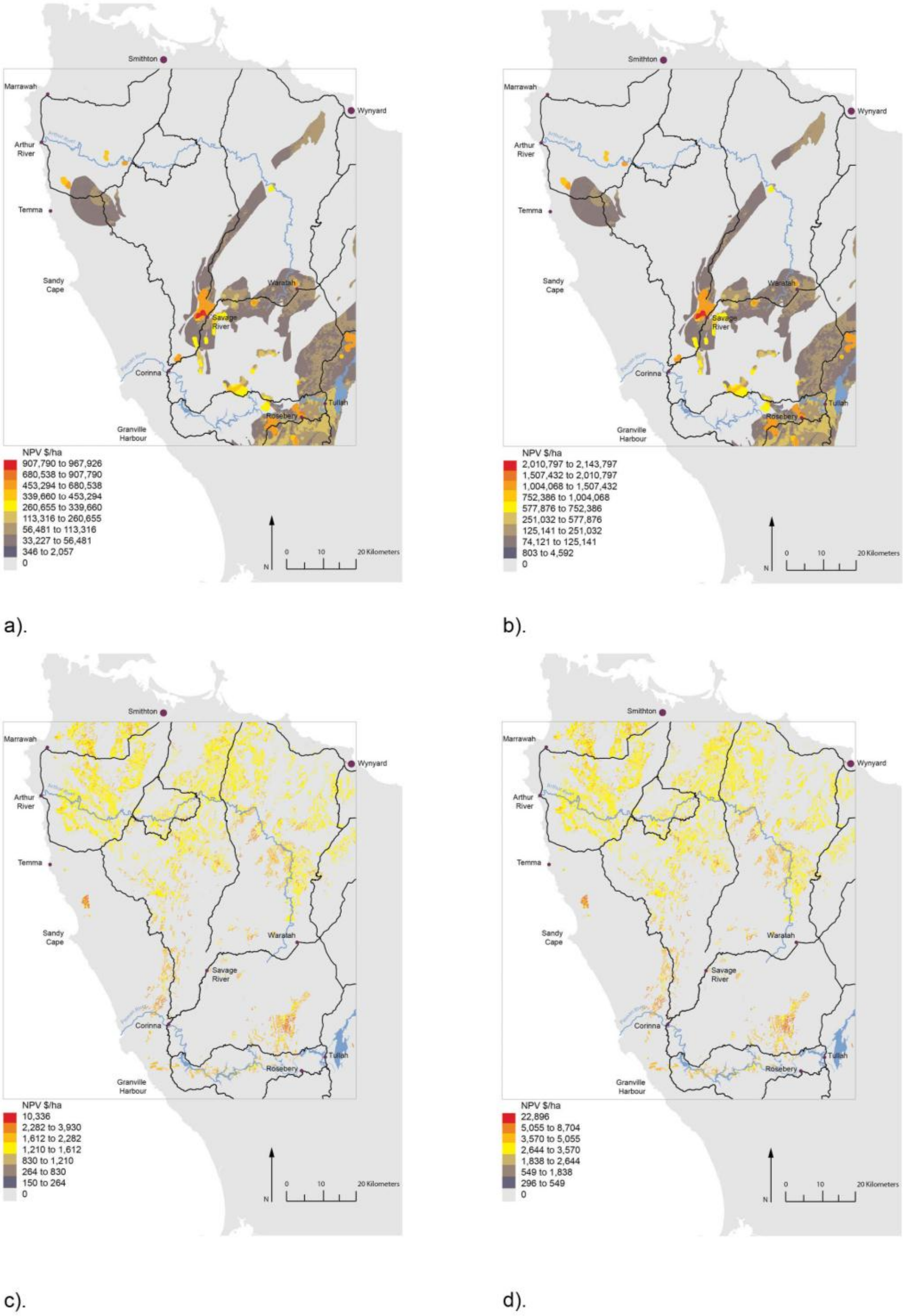

Figure 3.4 – Development priorities (excluding output multipliers).

(Where mineral, wood, tourism and carbon resource values are positive and occur in the same polygons and are therefore contested, a) where mineral and wood resources have higher economic value than tourism and carbon resources (MW 10-4 total area 147,959 ha), b) MW 7-10 total area 147,959 ha, c) where tourism and carbon resources have higher economic value than mineral and wood resources (TC 10-4 total area 72,256 ha) and d) TC 7-10 total area 72,256 ha).

Table 3-21 – Areas in which development priorities gave the greatest net present value (excluding output multipliers).

Development option	Total area (ha)	% of total study area	Total area of highest value (ha)	Highest value as % of total area (%)	Total area of lowest value (ha)	Lowest value as % of total area (%)	Total area of minerals (ha)	Minerals as % of total area (%)	Total area of wood (ha)	Wood as % of total area (%)	Total area of tourism (ha)	Tourism as % of total area (%)	Total area of carbon (ha)	Carbon as % of total area (%)
MW 7-4	**147,957**	**17.43**	**483**	**0.33**	**108,290**	73.19	**147,957**	**100.00**	8,972	6.06	**61,991**	**41.90**	**145,812**	98.55
MW 10-4	**147,957**	**17.43**	**483**	**0.33**	**108,290**	73.19	**147,957**	**100.00**	8,972	6.06	**61,991**	**41.90**	**145,812**	98.55
MW 7-10	**147,957**	**17.43**	**483**	**0.33**	**108,290**	73.19	**147,957**	**100.00**	8,972	6.06	**61,991**	**41.90**	**145,812**	98.55
MW 10-10	**147,957**	**17.43**	**483**	**0.33**	**108,290**	73.19	**147,957**	**100.00**	8,972	6.06	**61,991**	**41.90**	**145,812**	98.55
TC 7-4	72,256	8.51	12	0.02	57,101	**79.03**	14	0.02	**72,242**	**99.98**	5,340	7.39	72,256	**100.00**
TC 10-4	72,256	8.51	12	0.02	57,101	**79.03**	14	0.02	**72,242**	**99.98**	5,340	7.39	72,256	**100.00**
TC 7-10	72,256	8.51	12	0.02	57,101	**79.03**	14	0.02	**72,242**	**99.98**	5,340	7.39	72,256	**100.00**
TC 10-10	72,256	8.51	12	0.02	57,101	**79.03**	14	0.02	**72,242**	**99.98**	5,340	7.39	72,256	**100.00**

Development priorities where mineral, wood, tourism and carbon resource values are positive and occur in the same polygons and are therefore contested. Highest values in bold, highest value = 20% of the highest $NPV / ha values and lowest value = 20% of the lowest $NPV / ha values.

Table 3-22 – Areas in which development priorities gave the greatest net present value (including output multipliers).

Development option	Total area (ha)	% of total study area	Total area of highest value (ha)	Highest value as % of total area (%)	Total area of lowest value (ha)	Lowest value as % of total area (%)	Total area of minerals (ha)	Minerals as % of total area (%)	Total area of wood (ha)	Wood as % of total area (%)	Total area of tourism (ha)	Tourism as % of total area (%)	Total area of carbon (ha)	Carbon as % of total area (%)
MW 7-4	**243,737**	**28.72**	**506**	**0.21**	**224,625**	92.16	**180,916**	**74.23**	**82,929**	34.02	**72,075**	29.57	**239,866**	98.41
MW 10-4	**243,737**	**28.72**	**506**	**0.21**	**224,625**	92.16	**180,916**	**74.23**	**82,929**	34.02	**72,075**	29.57	**239,866**	98.41
MW 7-10	**243,737**	**28.72**	**506**	**0.21**	**224,625**	92.16	**180,916**	**74.23**	**82,929**	34.02	**72,075**	29.57	**239,866**	98.41
MW 10-10	**243,737**	**28.72**	**506**	**0.21**	**224,625**	92.16	**180,916**	**74.23**	**82,929**	34.02	**72,075**	29.57	**239,866**	98.41
TC 7-4	40,805	4.81	13	0.03	40,752	**99.87**	0	0.00	40,765	**99.90**	20,601	**50.49**	40,765	**99.90**
TC 10-4	40,805	4.81	13	0.03	40,752	**99.87**	0	0.00	40,765	**99.90**	20,601	**50.49**	40,765	**99.90**
TC 7-10	40,805	4.81	13	0.03	40,752	**99.87**	0	0.00	40,765	**99.90**	20,601	**50.49**	40,765	**99.90**
TC 10-10	40,805	4.81	13	0.03	40,752	**99.87**	0	0.00	40,765	**99.90**	20,601	**50.49**	40,765	**99.90**

Development priorities where mineral, wood, tourism and carbon resource values are positive and occur in the same polygons and are therefore contested. Highest values in bold, highest value = 20% of the highest $NPV / ha values and lowest value = 20% of the lowest $NPV / ha values.

3.4.3 Spatial sensitivity analysis using output multipliers

Output multipliers were applied to development resources (minerals, wood, tourism and carbon) revenues (Figure 3.8) to create eight development priorities (Figure 3.9). There was an increase in the area of viable mineral and wood resources (Figure 3.8a and Figure 3.8b) and no change in the total area of viable tourism and carbon resources (Figure 3.8c and Figure 3.8d). There was an increase in the total area of viable MW polygons (Figure 3.9a and Figure 3.9b) and a decrease in the total area of viable TC polygons (Figure 3.9c and Figure 3.9d). A large area of the wood and tourism resource became contested when output multipliers were used (Figure 3.10b and Figure 3.10c). A large area of the carbon resource became contested when output multipliers were not used (Figure 3.10d). The mineral resource had a large common area that was contested when output multipliers were used and were not used (Figure 3.10a). The most contested areas for competing resources were located within the mineral resource footprint (Figure 3.11a).

The MW development priorities were most sensitive to the use of output multipliers, which increased in total area by 64% (95,780 ha) compared to TC development priorities that decreased in total area by 43% (31,451 ha) (Table 3-23). The application of alternative discount rates and time periods did not alter the total area of the development priorities for either the use or non-use of output multipliers.

Table 3-23 – Total areas for development priorities.

	Total area (ha)			
Development option	**4 years (no multiplier)**	**10 years (no multiplier)**	**4 years (with multiplier)**	**10 years (with multiplier)**
7% discount rate (Minerals and wood)	147,957	147,957	**243,737**	**243,737**
7% discount rate (Tourism and carbon)	72,256	72,256	*40,805*	*40,805*
10% discount rate (Minerals and wood)	147,957	147,957	**243,737**	**243,737**
10% discount rate (Tourism and carbon)	72,256	72,256	*40,805*	*40,805*

Highest values in bold and lowest in italic.

The MW development priorities and the mineral resource had the largest increase in total area as a consequence of using output multipliers. The distribution and total area of MW and mineral polygons were the most consistent of all development priorities and resources when multipliers were applied and when no multiplier was used (Figure 3.5). This was due to the influence of the high NPVs $/ha associated with mineralised areas of high geological potential. These included mineralised areas around the Meredith Halo, areas of medium mineral potential north of Corinna and in the Norfolk Range and large areas of wood resources (*Eucalyptus obliqua*) to the north (Figure 3.9a and Figure 3.9b, Figure 3.8a and Figure 3.8b). The increase in total area for MW priorities when output multipliers were used generated a 19% increase in the total area of polygons of lowest 20% NPV $/ha value (116,335 ha) and an increase of 23 ha (0.1%) of highest 20% NPV $/ha value (Table 3-22). The increased area of low NPV $/ha values for the MW development priorities were due to the wider distribution of the wood resource under the output multiplier scenario.

The wood resource had the greatest increase (824%, 73,961 ha) in areas with higher economic value when output multipliers were used, followed by the tourism resource (284%, 15,261ha). The carbon resource decreased (-44%, -31,451 ha) in area when output multipliers were used; this was due to larger areas of wood resource that became viable as a result of multipliers and the higher NPV $/ha values for wood than carbon. The mineral resource was the most spatially stable economic resource when output multipliers were applied, yielding the smallest percentage and total area variation (22%, 32,959 ha) (Figure 3.5).

The MW development priorities were the most sensitive to output multipliers, creating the greatest percentage and absolute increase in total NPV, mean NPV $/ha and area (Figure 3.6 and Figure 3.7). Although the increase in total NPV and mean NPV $/ha of MW priorities was dramatic compared to TC priorities, the increase in total area was relatively moderate in comparison to TC priorities. The increase in total area was due to MW NPVs reaching a tipping point where road and rail infrastructure costs in marginal areas were absorbed by potential mining revenues. The mineral resource had significant economic viability constraints that the other development resources did not have, requiring large increases in NPVs to shift the distribution of postive (NPVs >0) polygons. The output multipler was applied to mining revenues which were much higher than the operating profit figures used in the non multiplier scenarios, thus ignoring the high input costs of mining and increasing profitability. For example, under the MW 10-4 output multiplier senario, the NPV $/ha increased by 353% from 4,893 to 22,209, thus shifting marginal polygons from unviable to viable, compared to TC 10-4 output multipler priorities where the NPV $/ha increased by 133% (from 18,2666 to 42,576). The tourism resource had the greatest increase in maximum NPV $/ha (816%) when output multipliers were used (Table 3-19). This was due to differing valuation methods between the non-multiplier and output multiplier scenarios, (i.e. a mean gross operating profit per visitor night was used to calculate discounted benefits in the non-multiplier valuation, whereas total tourism revenue was used in the output multiplier priorities by multiplying total potential visitor nights and expected gross profits per average visitor night spend). This increase created new areas where tourism values where higher than mineral or wood values around the Pipeline Plateau, Meredith Range, South Arthur Forests and Corinna involving *Nothofagus cunninghamii* forest (Figure 3.10c). These areas were not contested under the non-multiplier scenarios, as the wood values were negative (NPVs <0).

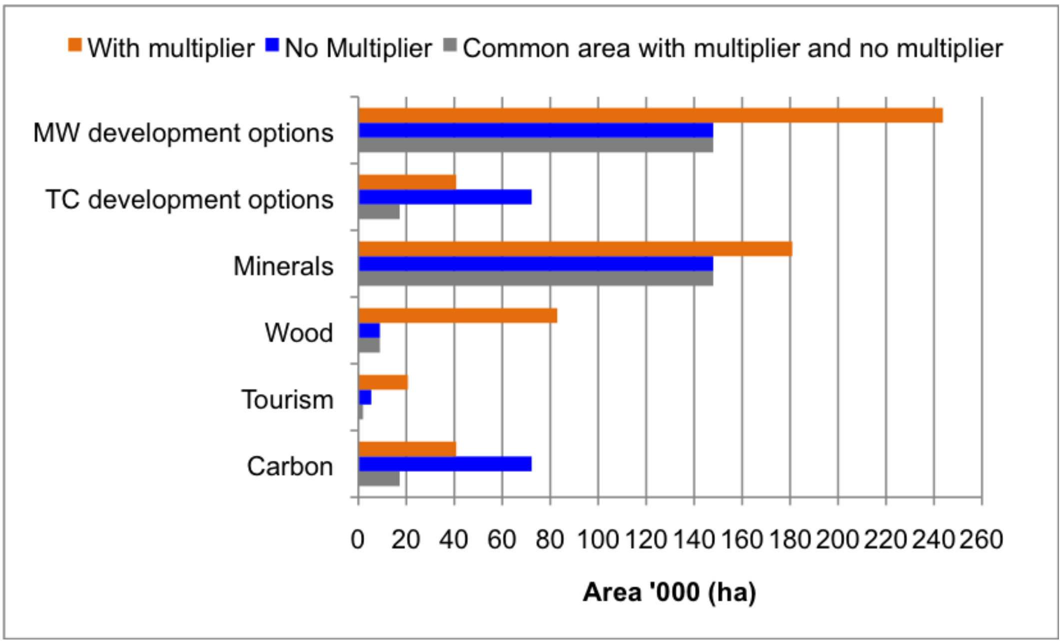

Figure 3.5 – Total areas of development priorities and resources.

(MW = mineral and wood development priorities, TC = tourism and carbon development priorities, with multiplier = development priority or resource polygons where output multipliers were used, no multiplier = development priority or resource polygons where output multipliers were not used, common area with multiplier and no multiplier = coinciding development priority or resource polygons where output multipliers were used and were not used).

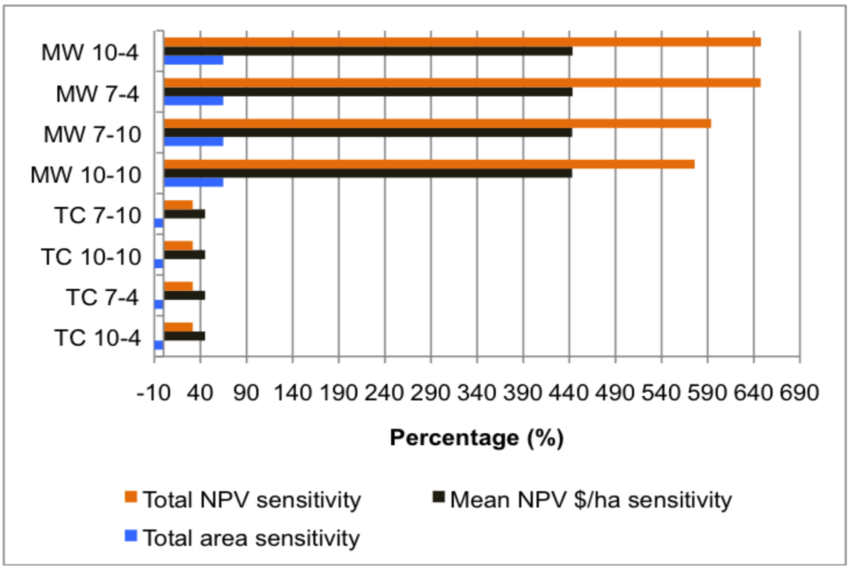

Figure 3.6 – Multiplier development priority sensitivity.

(Multiplier development priority sensitivity. MW = mineral and wood development priorities, TC = tourism and carbon development priorities, 7-4 = 7% discount rate p.a. over 4 years, 7-10 = 7% discount rate p.a. over 10 years, 10-4 = 10% discount rate p.a. over 4 years and 10-10 = 10% discount rate p.a. over 10 years. Total NPV sensitivity = the total increase from non-multiplier NPV to multiplier NPV (non-multiplier NPV subtracted from multiplier NPV) as a percentage of the original non-multiplier NPV amount. The same equation was used to calculate mean NPV and total area sensitivity figures).

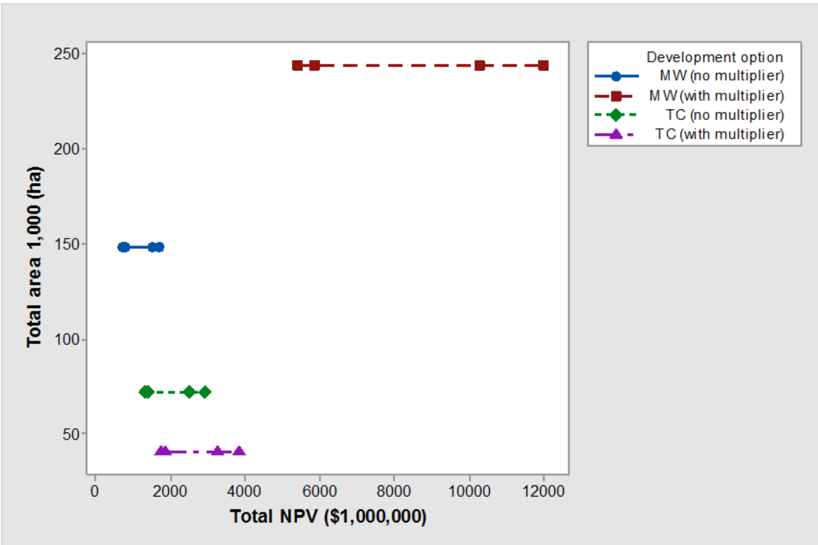

Figure 3.7 – Multiplier and non-multiplier development priority sensitivity.

(MW = mineral and wood development priorities and TC = tourism and carbon development priorities).

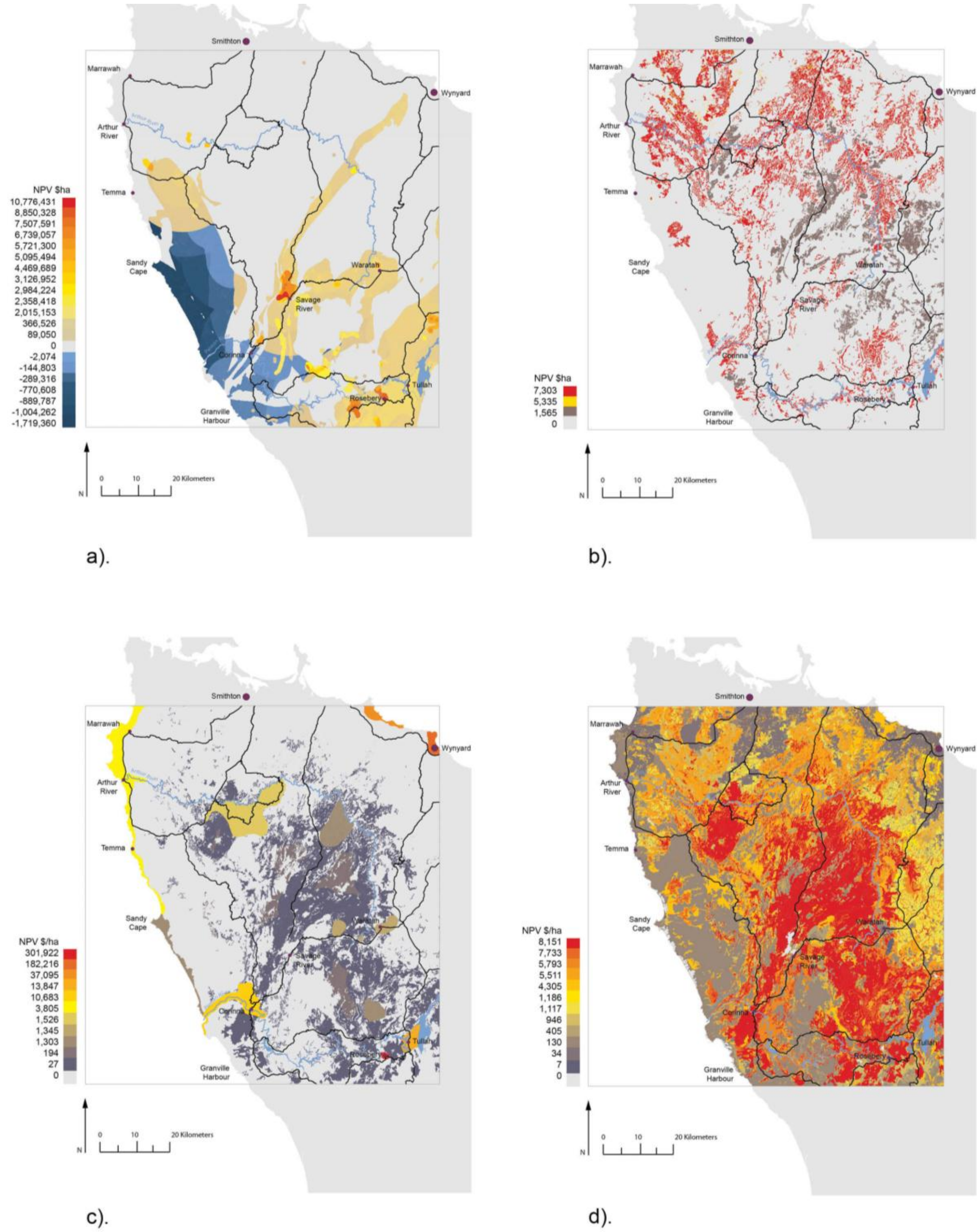

Figure 3.8 – Net present value ($/ha) of development resources.

(At 7% discount rate p.a. over 10 years for a) minerals, b) wood, c) tourism and d) carbon using output multipliers).

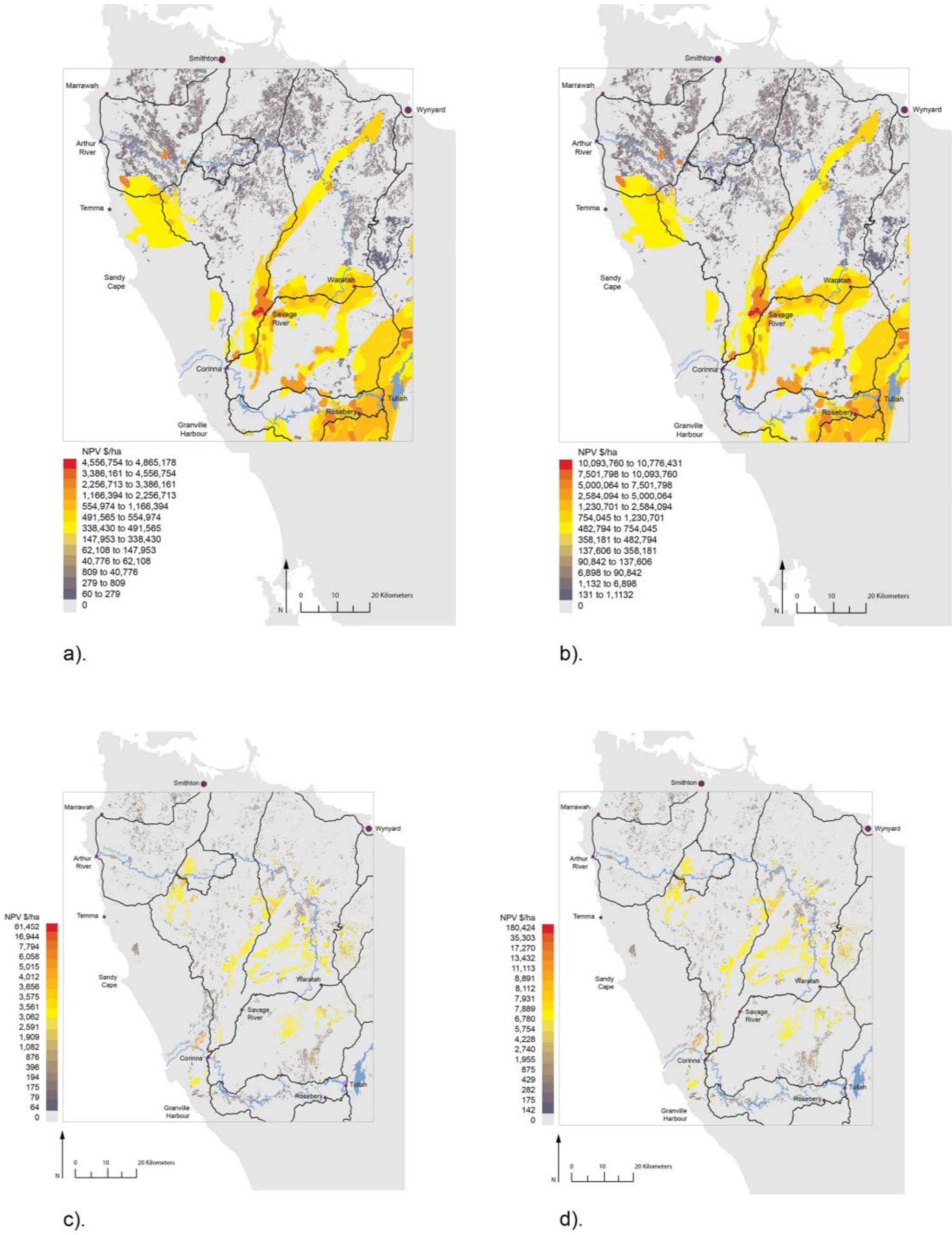

Figure 3.9 – Development priorities (using output multipliers).

(Where mineral, wood, tourism and carbon resource values are positive and occur in the same polygons and are therefore contested, a) where mineral and wood resources have higher economic value than tourism and carbon resources (MW 10-4 total area 243,737 ha), b) MW 7-10 total area 243,737 ha, c) where tourism and carbon resources have higher economic value than mineral and wood resources (TC 10-4 total area 40,805 ha) and d) TC 7-10 total area 40,805 ha).

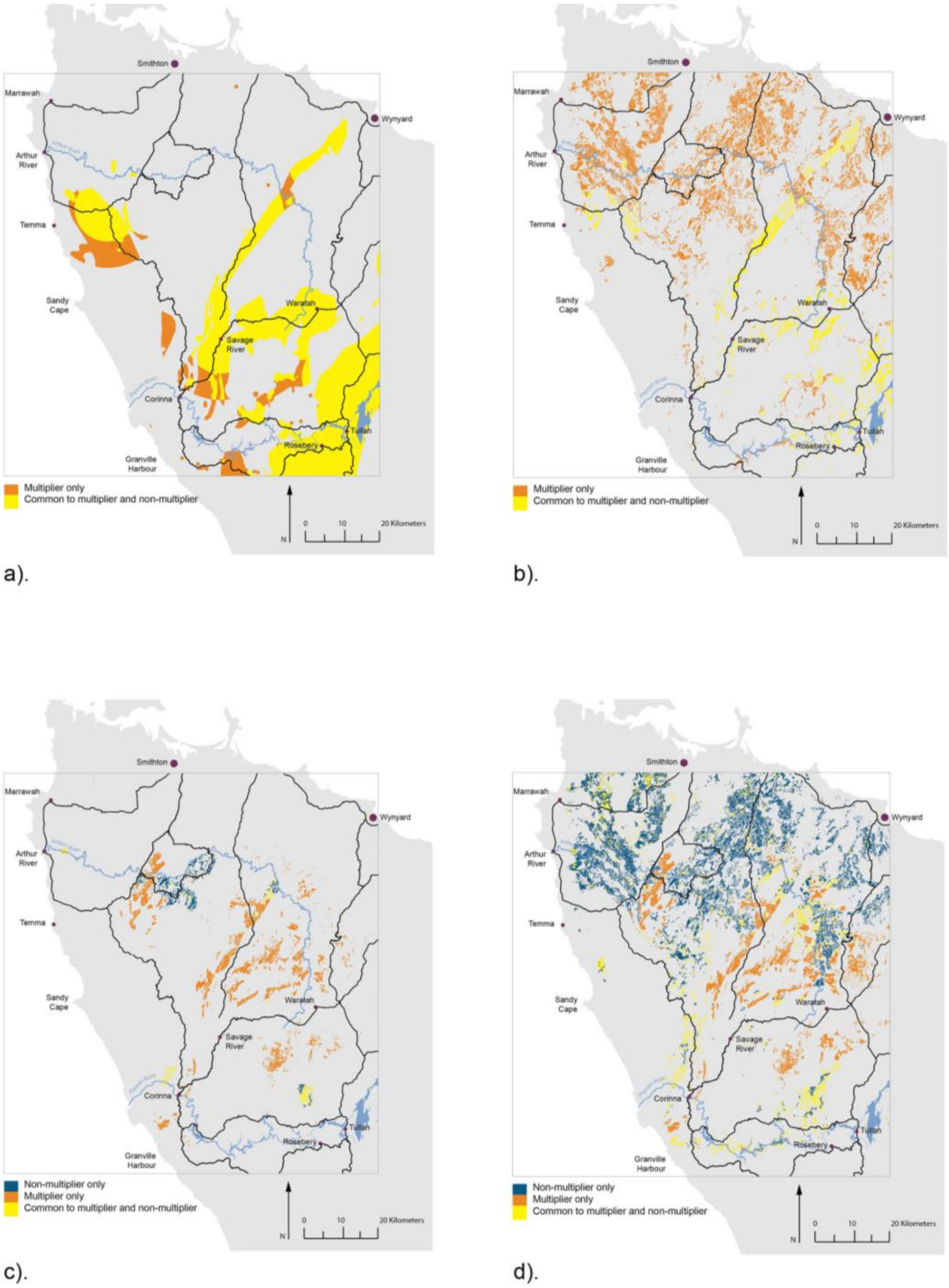

Figure 3.10 – Contested areas for development priorities.

(Development priorities where mineral, wood, tourism and carbon resource values are positive and occur in the same polygons and are therefore contested. Contested areas for development resources where economic multipliers and non-multipliers were used (common) and areas where development resources were identified for either using economic multipliers or non-multipliers (uncommon), a) mineral resource, b) wood resource, c) tourism resource and d) carbon resource).

When the output multipliers were used the minimum NPV $/ha values of the wood resource increased by 1,446% (Table 3-19), shifting large areas (62,820 ha Eucalyptus obliqua in the north and 23,589 ha Nothofagus cunninghamii forests) into contestation (Figure 3.11b). This created a reduction in the total area for carbon resources by 44% (from 72,598 ha under the non-multiplier scenarios to 40,805 ha under the output multiplier scenarios) as E. obliqua forest shifted from having higher carbon values to higher wood values and N. cunninghamii forests changed from not being in contention to having higher tourism and carbon values.

The total area of competing resources in common areas was 165,247 ha (Figure 3.11a) and represented 58% of the total area of the combined development resource footprint compared to 119,508 ha (42%) of area of competing resources in uncommon areas (Figure 3.11b). The most concentrated areas for competing development resources for both non-multiplier and mutlipler scenarios were the Pipeline Corridor and areas around Waratah and the Murchison Highway (Figure 3.11a).

The application of output multipliers therefore favoured MW development priorities rather than conservation land use (TC) by a) creating the greatest increase in wood resources and thus reducing carbon resources in the north of the Tarkine and b) creating consistently high NPVs for high mineral prospectivity areas common to multiplier and non-multiplier scenarios.

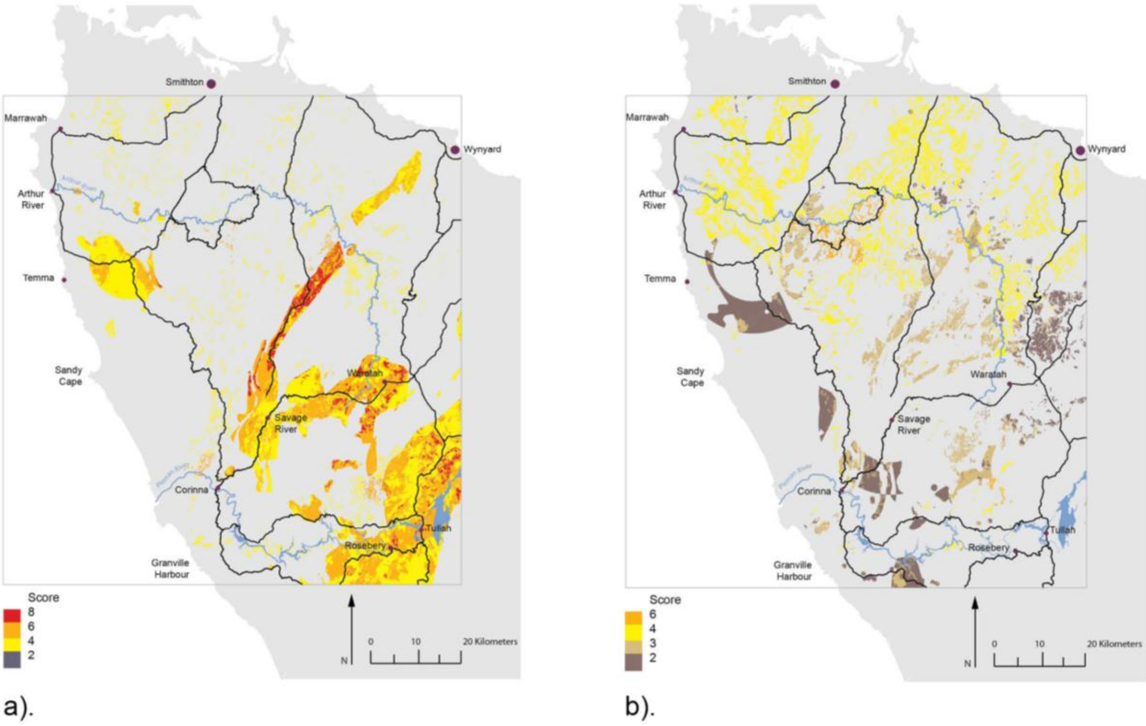

Figure 3.11 – Resource concentration index.

(Resource concentration index, areas of multiple development resources where mineral, wood, tourism and carbon resource values (using multipliers and non-multipliers) are positive and occur in the same polygons and are therefore contested, a) total number of competing development resources in common areas and b) total number of competing development resources in uncommon areas).

3.5 Discussion

3.5.1 Development resources in the Tarkine and their relative economic value

The economic value of mineral resources in the Tarkine were consistent with reported revenues, were slightly higher for total mineral prospectivity and represented a mid range value for mineral activity in 2013. The mean reported annual revenue from the mineral industry in Tasmania from 2009 to 2013 was $823,800,000 and ranged between $136,000,000 of gross operating surplus (GOP) and gross mixed income (GMI) p.a. to $988,000,000 gross revenue p.a. (ACIL 2009; ABS 2010; Tasmanian Government 2013c, 2014; Nichol, Shi & Campi 2013b and Grants Commission 2014). The estimated gross revenues for mines operating in the Tarkine in 2013 totalled $635,616,655 and were 92% of the value of the gross revenue[7] ($692,040,000) for the 2012-13 year (Grants Commission 2014). The total gross revenue in the analysis for current and proposed mines in 2013 in this thesis was $1,303,197,010, 130% of the total production value ($998,000,000) of mines in the Cradle Coast Region (Nichol, Shi & Campi 2013b). The NPVe (year 1) estimate for operating mines in 2013 was $98,125,869, 98% of the equivalent value[8] of gross operating surplus (GOP) and gross mixed income (GMI) of mines reported by Tasmanian Government (2014) for the Tarkine at $99,280,00. However, it is recognised that GOP and GMI values exclude some deductions that NPV values do not, therefore the difference between the NPVe (year 1) estimate in this thesis and GOP and GMI may be slightly greater.

The valuing of wood resources in the Tarkine using the biological production function model resulted in a value that was lower (mean 52%[9]) than the current market. This result was expected, as current harvest rates in Tasmania are double the sustained yield (West, cited in Darby 2012b). Others have valued wood resources in the Tarkine and Tasmania using total current harvest rates (m^3/p.a.) and MDLV/m^3 ($) per forest resource type without NPV methods (Mesibov 2002; Timber Workers for Forests 2004; O'Hara, Farley & Smith 2013). Therefore using harvest rates as an indication of economic value was the most appropriate method for comparing the results in this thesis. The sustainable harvest rate[10] for tall

7 Mineral values were reported for the entire State, these were adjusted by 73% to reflect the proportional share of mineral wealth contributed by mines in the Tarkine according the Tasmanian Government (Tasmanian Government 2013c).

8 Mineral values were reported for the entire State, these were adjusted by 73% to reflect the proportional share of mineral wealth contributed by mines in the Tarkine according the Tasmanian Government (Tasmanian Government 2013a).

9 This excludes the harvest rates for the DRM resource (Mesibov 2002) as targeted resources differed from the present study.

10 This rate has been calculated for forest resources in the Tarkine that were available for harvest according to current reserve status.

Eucalyptus obliqua forest was 165,064 m^3/p.a. and 52% of current harvest rates of 318,180 m^3/p.a. (Timber Workers for Forests 2004; O'Hara, Farley & Smith 2013). The results in this thesis indicated that the sustainable harvest rate[11] for tall *Acacia melanoxylon* forest was 2,091 m^3/p.a. and 28% of current harvest rates of 9,355 m^3/p.a. (Timber Workers for Forests 2004). The sustainable harvest rate for tall *Nothofagus cunninghamii* forest was 6,509 m^3/p.a. and 260% higher than those suggested by Mesibov (2002). This variation was due to different harvest modes and time frames, as high quality DRM forest was targeted for selective logging over a 16-year time frame at a rate of 2,498 m^3/p.a. (Mesibov 2002), compared to the current study that considered all tall *Nothofagus cunninghamii* forest over a continuous harvest mode regardless of reserve status. However, the harvest rate for tall *Nothofagus cunninghamii* forest was 80% of the harvest rate reported for *Nothofagus cunninghamii* and other minor species in the Tarkine of 8,100 m^3/p.a. (Timber Workers for Forests 2004). When combined, the harvest rate in this thesis for tall *Acacia melanoxylon* forest and tall *Nothofagus cunninghamii* (8,600 m^3/p.a.) was 49% of the estimate for total specialty timbers at 17,455 m^3/p.a. (O'Hara, Farley & Smith 2013).

The valuation of the tourism resource was within the economic value range of others (EMDA, Moore Consulting & SCA Marketing 2007b; Felmingham & Wadsley 2008). EMDA, Moore Consulting & SCA Marketing (2007b) valued tourism in the Tarkine using a simple approach of multiplying expected visitor nights and average visitor spend over 7 years, with no discount rate, resulting in a total valuation range of $9,600,000 to 58,200,000, dependent upon infrastructure investment (specifically road upgrades such as the Tarkine Drive). Average annual visitor numbers were estimated at 24,662 with a mean annual value of $4,842,857 (EMDA, Moore Consulting & SCA Marketing 2007b), compared to the results in this thesis that totalled 31,976[12] with a NPV (year 1) revenue value of $ 4,264,703, which equated to a 30% variation in visitor numbers and 12% variation in revenue. This revenue difference was due to the use of gross operating profit per visitor night in this current study. The visitor numbers in the present study included latent demand for guided tours, old growth rainforest and wilderness tours and Tarkine Drive experiences (Inches 2010; Fry 2014), which were not included in the latent demand quantification by EMDA, Moore Consulting & SCA Marketing (2007b). Felmingham & Wadsley (2008) valued the Tarkine Drive using the NPV method with a discount rate of 7% p.a. over 10 years, including costs for road construction, visitor facilities and other minor costs totalling $1,140,000. The results for the valuation of the Tarkine Drive using the same NPV inputs in

11 This rate has been calculated for forest resources in the Tarkine that were available for harvest according to current reserve status.

12 Visitor numbers p.a. for Rocky Cape, Rosebery and Wynyard were omitted from this figure to allow for comparison with the EMDA definition of the Tarkine destination.

this thesis was $944,785, equating to a 17% variation due to cost exclusions such as visitor facilities and other minor costs in the present analysis.

The carbon resource in Tasmania has been valued by others using the NPV method and widely varying inputs for discount rates, time frames, leakage factors, risk buffers, above and below ground carbon mass accumulation rates, net primary productivity and gross primary productivity ratios and carbon trading prices (May et al. 2012; Macintosh 2012b; May 2016), thus making comparisons difficult as all inclusions and exclusions were not clear. May et al. (2012) used a 3% discount rate p.a. over 40 years with variable rates for leakage and risk buffers and $5.00 carbon-trading price to value the carbon resource in Tasmania. Macintosh (2012b) used a 7% discount rate p.a. over 19 years (with or without a 10% leakage rate) and a $10.00 carbon-trading price to value the carbon resource in Tasmania. May (2016) used 2%, 3% and 4% discount rates p.a. over 40 years with a 5% risk buffer and $13.12 carbon-trading price to value the greenhouse gas abatement for cessation of native forest harvesting. Total carbon credits/ha/yr[13] (tC ha^{-1} yr^{-1}) were used to compare the present results with others as this process provided a simple way of understanding the carbon value independent of other factors. As the present results included tC ha^{-1} yr^{-1} for agriculture and non-forested land, below ground carbon mass accumulation rates and an old growth forest component, these elements were excluded in order to make comparisons with the results of others.

May et al. (2012) valued the carbon resource in Tasmania under multiple scenarios. Their N5 scenario of immediate cessation of all native forest harvesting was used as a comparator, which indicated 12.81 tC ha^{-1} yr^{-1} (no leakage or risk buffer) and 11.09 tC ha^{-1} yr^{-1} (with 15.5% leakage and risk buffer). Macintosh (2012b) estimated the carbon resource for the reserves proposed under the failed forest agreement at 17.18 tC ha^{-1} yr^{-1} (no leakage), 15.47 tC ha^{-1} yr^{-1} (with 10% leakage). Keith et al. (2010) estimated maximum carbon carrying capacity of native forests in southeast Australia at 18.00 tC ha^{-1} yr^{-1}. The present results indicated a mean rate of 22.50 tC ha^{-1} yr^{-1} (no leakage) and 19.01 tC ha^{-1} yr^{-1} (with 15.5% leakage and risk buffer), equating to a mean variation of 45% with the results of others (73% mean variation with May et al (2012), 27% mean variation with Macintosh (2012b) and 25% variation with Keith et al. 2010). The large variation between the present results and May et al. 2012 were due to their strong discounting of carbon emissions, which reduced the carbon sequestration potential as identified by Dean and Kirkpatrick (2012). May et al. (2010) used a 1 km x 1 km raster grid cell for their calculations which is relatively coarse in comparison

13 This value excluded below ground, old growth forest, non-forest, agricultural land and forest plantation annual carbon increment of carbon mass and accumulation rates.

to the vector resolution of TasVeg 2.0 used in the present analysis, which may have also contributed to differing results.

Although the present results for the value of the carbon resource were higher than others, they did not distort the spatial relationships between carbon and the other development resources (minerals, wood and tourism). For example, if a 15.5% leakage and risk buffer was discounted from the present results in this thesis and a $5.00 carbon trading price was used, the NPV range for carbon in the Tarkine would be $350,954,398 (using a 10% discount rate p.a. over 4 years) to $777,365,934 (using a 7% discount rate over 10 years). Similarly if above and belowground carbon mass accumulation rates (tC ha^{-1} yr^{-1}) were reduced by 45% and a $13.95 carbon trading price was used, the NPV range for carbon in the Tarkine would be $679,543,634 (using a 10% discount rate over 4 years) to $1,505,192,911 (using a 7% discount rate over 10 years). These alternative NPVs would be higher than NPVs of the wood and tourism development resources in each relevant discounted time frame, and within the same range as the mineral resource. Therefore the carbon resource remained as the most economic resource outside the positive NPV mineral resource areas.

3.5.2 Social relevance of development priorities

The provision of transport infrastructure is central to economic development as accessibility costs affect development opportunities (Spoehr, Burgan & Molloy 2012). The present results indicated that the transport infrastructure cost of the tourism resource was minimal. The tourism resource had a mean benefit-cost ratio (BCR) of revenue to transport costs of 21.21 and a mean return on investment (ROI) of 20.21. The transport costs of the mineral and the carbon resources were similar, but the discounted benefits of the carbon resource were higher resulting in a mean BCR of 25.75 and mean ROI of 24.75 across all NPV models compared to a mean BCR of 14.01 and ROI of 13.01 for the mineral resource. The transport costs for the wood resource were highest, with a mean BCR of 1.91 and ROI 0.91. Mineral royalty revenue covered transport infrastructure costs of some mines, whilst in others it represented a large economic shortfall. The royalties from mines with higher NPV and longer lives were subsidising others as these mines were located near to existing developed transport infrastructure and port facilites and were less likely to require transport cost subsidisation. The total transport costs of these mines (approximately half of all mines assessed) represented 70% of the total expected mineral royalties. The expected royalities from mines that were either remote from existing transport infrastructure, involved extraction of lower valued minerals, incurred HPV costs or had a short working life with small returns on average covered 34% of total transport costs. The current transport network that supports mineral prospective areas with positive NPVs has deficiencies. The Melba rail line is in poor asset condition and supports fewer mines than in the past and some of the local road network does not meet HPV standards (SKM 2012). Although this may ultimately constrain the development of the mineral resource, subsidisation of road infrastructue would have social benefits by provisioning a safe public transport network to service isolated communities in western Tasmania.

The carbon market has been criticised as ‘climate capitalism’ and another form of neoliberalism, hindering the development of more sustainable practices by allowing foreign entitites to buy credits whilst continuing to emit (Böhm, Ceci Misoczky & Moog 2012; Lohman 2009). Despite the commodification of carbon, forest carbon sequestration provides global public good and forests generate multiple social benefits (e.g. ecosystem services and subsistence needs) (Chhatre & Agrawal 2009). However, the efficiency and political legitimacy of market based instruments such as carbon trading can be reduced where there is significant conflict among stakeholders (Lockie 2012), for example, over loss of jobs. It is expected that, in the medium term, employment created by carbon markets will be more than that lost from traditional sources, and likely to involve jobs in non-energy industries (Frankhauser, Sehlleier & Stern 2008). In the short term, direct employment where native forest is protected for carbon markets may be limited as production and transaction costs are low and may involve forest restoration and development control activities to reduce leakage risks (Smith & Scherr 2003; Edwards, Fisher & Boyd 2010). Some suggest that carbon market revenues could be redistributed to deliver social or environmental outcomes to compensate for local employment effects (Law et al. 2012).

There are gross uncertainties in regard to the reality of carbon markets, as they are fully liquid and have massive risk and transaction costs (Campiglio 2014; Matsumoto, Tachiiri & Kawamiya 2016). Avoided public native forest harvesting is currently not eligible for carbon trading under Australian Federal law (Perkins & Macintosh 2013; May 2016) and it is unclear if this restriction may be removed in the future, thus potential carbon trading in Tarkine is subject to significant unknown factors.

Although the REDD+ (Reducing Emissions from Deforestation and Forest Degradation) scheme remains as the principal framework for forest carbon sequestration post Paris Agreement, it is only available to developing countries and has been questioned for its effectiveness (Okereke & Dooley 2010; Strek, Keenlyside & von Unger 2013; Seyller 2016). In Australia, the reduction or cessation of native forest harvesting allows the Australian Government to record emission reductions under the Kyoto Protocol using Forest

Management Credits (FMC) (Perkins & Macintosh 2013). Land holders can sell carbon credits to preserve native forest on private land through the Carbon Farming Initiative (CFI) as part of the Australian Government Emissions Reduction Fund (ERF) (Australian Government 2016). Small land holders in Tasmania have sold carbon credits through this scheme (Kearney 2012; Climate Friendly 2015), despite problems with economies of scale (Merger, Dutschke & Verchot 2011). There are land tenure limitations which influence eligibility of native forest for carbon trading. Native forests in national parks have been excluded from generating carbon credits (Law 2013). However, FMCs generated from potential new reserves under the failed Tasmanian Forest Agreement were allocated to the Australian Government (Macintosh 2012b). Some argue that the preservation of native forest could lead to Australian Carbon Credit Units (ACCUs) being available under the CFI, if legislative changes were made to allow States to participate in the CFI and generate ACCUs (Perkins & Macintosh 2013).

There have been calls for the establishment of international rules and mechanisms to deliver consensus on ecosystem carbon trading (Mansell 2015). Interested Governments could create market linkages and transfer market units for carbon pricing rather than wait for market regulation problems to be resolved (Turvey 2013; Mansell 2015). Future voluntary markets might value forest for more than carbon sequestration to include biodiversity credits so as to better reflect non-market benefits (Turvey 2013; Torabi & Bekessy 2015). Until the Australian Government (in cooperation with the Tasmanian Government) allows the preservation of native forest on Crown land regardless of tenure to be eligible for carbon trading under the CFI, then the monetary value of the Tarkine's ecosystem carbon will remain potential, not actual.

It is uncertain how climate change may affect carbon stocks in the Tarkine. Although the total annual rainfall in western Tasmania is not expected to vary under climate change (Grose et al. 2013) rainforest communities remain sensitive to climate change (Baker 2013; Styger 2014). Even though recent increases in lightning storms and warm summer seasons in Tasmania (Bowman 2016) have caused major fire events, rainfall in the previous month has been found to be most important in predicting rainforest fire (Styger & Kirkpatrick 2015). Regardless of the direct economic benefits, climate change and market uncertainties, the protection of forest as a carbon market asset has biodiversity and ecosystem service benefits which are crucial to human well being (Grabowski & Chazdon 2012).

While the results showed that mines had an average life span of approximately 10 years, other values such as biodiversity, carbon mitigation and sustainable wood supply from a human perspective were infinite or had a ‘forever’ value. The application of conventional NPV timeframes and discount rates presented in this thesis provided a short term view of development options as opposed to the long term consequences of their implementation. As human population growth continues and the services that humans derive from ecosystems are depleted, solutions are required to minimise irreversible changes to biological diversity (Chapin et al. 2000; McKee 2005). There have been substantial attempts to provide economic models for sustainable development which take into account intergenerational equity (De Lara & Doyen 2008). The use of CBA / NPV methods to quantify natural values has been criticised for its imprecise and reductionist approach, which fails to recongnise the limits and long term consequences of development or conservation options (Díez & Etxano 2008). Some argue that CBA / NPV methods might be useful in the short term when valuing infinite resources, but are best limited to a 30 year timeframe and a declining discount rate in order to reflect the risk associated with the economic uncertainty of the future (Hepburn & Gosnell 2014).

3.5.3 Potential for spatial variation

The results in this thesis demonstrated that from an economic point of view, most of the Tarkine was usable for carbon and tourism with localised use of mineral deposits. Commodity prices, visitor numbers and geological mineral potential were constraining land use patterns, with low probability of spatial variation resulting from potential market changes.

The footprint for wood resources is unlikely to expand as the market price for tall *Eucalyptus obliqua* forest would have to increase by 235% and tall *Nothofagus cunninghamii* forest by 944% in order to equal the highest NPV ($/ha) polygons for carbon resources. This scale of market increase is doubtful, as global demand for wood from natural forests is in decline (Warman 2014) whilst carbon markets are expected grow (Montagnini & Nair 2004; Newell, Pizer & Raimi 2013). Also, the NPV of the wood resource is more sensitive to costs (particularly roading and stumpage), compared to the NPV of the carbon resource, which was least sensitive to costs. Therefore it is unlikely that the spatial pattern would change in favour of more wood than carbon resources. Similarly, the market price for tall *Eucalyptus obliqua* forest would have to increase by 895% and tall *Nothofagus cunninghamii* forest by 4,073% in order to equal the highest NPV ($/ha) polygons for tourism resources.

The mineral deposits in the Tarkine are limited by geological potential, which is influenced by spatial overlaps between the Mount Read volcanics and the Devonian granite halos

(Large & McNeil 2012). Approximately 99.5% of the total areas of negative NPVs for the mineral resource are located in areas of medium geological potential and 0.5% in areas of high geological potential. In order for these areas to have neutral NPVs, VMSD mineral deposits commensurate with Rosebery would have to be found in these areas, combined with 233% increase in mine NPV to counter the transport cost impost to develop and maintain road infrastructure to service such a mine. Likewise, a high-grade silica flour deposit would have to be discovered in conjunction with a mine NPV increase of 799%. For mineral resource areas where NPVs are positive and coincide with the largest contiguous area of rainforest, total visitor night numbers for the guided tours market would have to increase by a factor of 2,955 (total of 283,632 p.a.) in order to equal the NPV ($/ha) polygons for mineral resources. This would equate to 2.8 times the total mean annual total overnight visitors to Cradle Mountain for 2012 to 2015 (TV Analyser Tourism Tasmania 2014). Whilst the rainforest in the Tarkine could provide Australia's longest rainforest multiday wilderness walk, it is unlikely to attract visitor numbers of this magnitude. These scenarios whilst not impossible are improbable, making the footprint for mineral resources in the present study realistic from a geological potential, economic and visitor destination perspective.

3.5.4 Degree of conflict between economic uses

Conflict was most likely to occur between tourism and mineral development along main access roads where mineral NPVs were highest. These localities provided the most viable areas for mining where aesthetic impact of open cut mines and settling ponds was likely to be highest. Another potential area of conflict was the Pipeline Corridor where mineral development would impact on carbon and conservation values. The current reserve system allowed for forestry development along the Corinna Road. This was likely to create conflict as Corinna continued to grow as a significant nature based destination in the Tarkine. Broadspread mineral exploration may continue to create conflict with rainforest wilderness tour guide experiences.

3.6 Summary

There is high economic potential for carbon and tourism development in the Tarkine with potential for localised mining activity. The development priorities presented were stable and the economic valuation and spatial differentiation between development priorities were robust. However, the application of output multipliers changed the results creating large areas of forest with greater economic value for logging than tourism and carbon combined.

Whilst NPV methods may not be the best way to measure social worth, it provided a relative indication of monetary value, appropriate for trade offs with other land use priorities. The economic valuations for mineral and tourism resources in this thesis were within the range of others. The wood resources were approximately half the value of the current market due to the use of the biological production function model. The carbon resource valuation was higher than others, due to the inclusion of agriculture and non-forested land, below ground carbon mass accumulation rates and an old growth forest component. Regardless of the deficiencies of the valuation of the carbon resource, alternative modeling for a lower carbon price and strong discounting still resulted in the highest NPV of all development priorities.

Transport infrastructure costs were highest in the mineral resource, followed by the wood resource. The carbon resource had the lowest input costs of all development resources. Spatial conflicts between economic resources related to localised mineral development occurred along major access roads and along the Pipeline Corridor, between mineral and tourism development and between mineral and carbon resources.

Chapter 4 Conflict in the Tarkine: triangulation of group attitudes, value preferences and conflict scenarios using PGIS processes

4.1 Chapter overview

The previous chapter determines the pattern of optimal economic use in the Tarkine. This chapter establishes individual and group attitudes and value preferences toward conservation and development options, conflict scenarios and willingness to compromise. The introduction reviews how people's attitudes toward the natural environment are developed, how attitudes may change and participatory processes used to facilitate compromise between conflicting parties. This chapter hypothesises that conflict is multidimensional; that informed discussion of values leads to increased willingness to compromise potential outcomes; and, that variation in such willingness is predictable. The context of environmental conflict in Tasmania is established. The methods section explains the data collection process using PGIS and the analysis of PGIS data (surveys, workshops discussions, map choices and mapping tasks). The results report on the attitudinal factors influencing people's views and values, attitude groups are established based upon statistical analysis of PGIS data and individual attitudes toward conflict scenarios are assessed. Spatial conflict according to attitude group, major conflict themes and willingness to compromise model are explained in the results. The discussion expands upon the findings that conflict is multidimensional and discusses the usefulness of the reciprocal triangulation of spatial and non-spatial data. The relevance of attitude groups and the role of informed discussion and its effect on willingness to compromise are discussed.

4.2 Introduction

Environmental conflicts relating to differences in preferences for the future of natural resources (Doak et al. 2013; Ives & Kendal 2014) are increasing (Escobar 2006; Bob & Bronkhorst 2012; Goetschel & Pe´clard 2012). Environmental conflicts involve numerous interest, agency and conflict arenas (Opotow & Weiss 2000; Hellström 2001; Balint et al. 2011; Walter 2012; Buchanan 2013). They cannot be solved by science alone (Taylor 1994; Cohn 2002; Buijs et al. 2011). Participatory practices are being used widely to move people from protracted conflict positions toward conflict compromise (Rauschmayer & Wittmer 2006; Dhiaulhaq et al. 2014). Facilitators of such conflict resolution practices need a deep understanding of values, attitudes and motivations to assist individual and group willingness to compromise (White et al 2009; Redpath et al. 2013).

There are many ways in which attitudes toward the environment are developed. Although contested, the use of mass media to inform the general population is recognised as having substantial influence on environmental attitudes (Tranter 1996). The potential to polarise debate is high as mass media often frame environmental conflict as a moralistic and ideological war between two opposing parties (Kirkpatrick 1987; Schwarze 2006; McCluskey & Kim 2012; Feinberg & Willer 2013; Fisher, Waggle & Leifeld 2013; Voyer et al. 2013). For any particular conflict, Carlisle and Smith (2005) argue that personal economic circumstances affect an individual's outlook ranging from individualism (supporting development) to egalitarianism (supporting reduction in development). Studies in Australia support this view, indicating that those in the 'production sector' value material goods highly compared with those in the 'service sector' and those who have grown up affluent who value clean environment highly (Tranter 1996). Environmental conflict can thus be perceived as ideological, a battle between self-interested neoliberals and those that believe they represent the interests of the environment (Wade-Benzoni et al. 2002; Bamberg & Möser 2007; Hayter & Barnes 2012; West 2013). Such conflict is popularised as the 'growthists' versus the 'greenies' (Kirkpatrick 1988; Poritt 2011). 'Growthists' believe that the global economy can expand indefinitely (Douglas 2007), whilst 'greenies' advocate conservation (Whitehouse 2014). This dualistic framing of environmental conflict may sell newspapers, but may not reflect the reality, given that land use conflicts may occur between different types of recreators, such as off-road vehicle enthusiasts and bushwalkers, different forms of development, such as forestry and agriculture, and different cultures, such as Indigenous and Western. It is therefore postulated, in the present thesis that, in any region, conflicts over land use are likely to be multidimensional rather than dualistic.

In the island state of Tasmania, Australia environmental disputes are embedded in local culture (Flanagan & Pybus 1990; Flanagan 2003; Beresford 2010; West 2013) and have been constant since the 1960's (Kirkpatrick 1988; Buckman 2008; Willadsen 2009; Affolderbach 2011; Koshin 2011). The future of wilderness preservation and forest protection is in dispute (Tranter 2009), involving disagreements over land use, land access and conservation and development ideologies (Koshin 2011). In the twenty-first century, environmental conflict in Tasmania involves forest management (Dickenson & Cannon 2004; Montgomery 2004; Hollander 2006; Hickey 2009; Darby 2014), world heritage area extensions (Mosely 2013; ABC 2015), paper pulp mill development (Gale 2009; Beresford 2010) and anti-protest and defamation laws (ABC 2014; Abey 2015, Smith 2015a; The Guardian 2015). Private businesses, unionists, conservationists, artists, governments and ordinary people are involved, with activists, business, politicians and mass media competing to control the conflict agenda (Lester & Hutchins 2009, 2012).

To date there have been attempts resolve environmental conflict in Tasmania through the Regional Forest Agreement (Kirkpatrick 1998; McDonald 1999) and the Tasmanian Forest Agreement (Tasmanian Government 2011a; Macintosh & Denniss 2012). One tool that has not been used in Tasmania is conflict mapping which is promoted as an effective tool in the process of resolution of conservation-development conflicts (Redpath et al 2013). It has been used since the 1980s to expose value differences between entrenched foes (Piccolella 2013). Public participatory GIS (PPGIS), participatory GIS (PGIS) and volunteered geographic information (VGI) processes, all forms of conflict mapping, have been used successfully in developing and developed nations (Brown & Kyttä 2014). Methods and approaches are experimental, only limited by the creativity of the researcher (Watts 2010).

There is an extensive literature demonstrating benefits of PGIS, participatory mapping and participatory spatial planning (Ball 2002; McCall 2003, 2012; Schlossberg & Shuford 2005; Rambaldi et al. 2006; Carton & Thissen 2009; Brown & Kyttä 2014). PGIS and PPGIS have been used to research a range of spatial issues, values and contexts. Conflict mapping research is abundant (e.g. Brody et al. 2004; Kwaku Kyem 2004; Reyes García et al. 2012; Raymond & Curtis 2013; Brown & Raymond 2014; Whitehead et al. 2014), as is mapping of development preferences (e.g. Nielsen-Pincus et al. 2010; Nielsen-Pincus 2011), conservation preferences (e.g. Raymond et al. 2009; Bryan et al. 2011), place attachment (e.g. Brown 2005; Brown & Raymond 2006), ecosystem services (e.g. Brown & Fagerholm 2014) and social-ecological hotspots (Karimi, Brown & Hockings 2015).

Piccolella (2013) argues that PGIS has the potential to empower communities who lack influence on complex world scale problems, while McCall (2003) states that it can express multifaceted relationships and valuing of natural environments traditionally unavailable to State agencies and technocrats. Countering these advantages, McCall (2003) also states that the visual geospatial representation of values through PGIS is masculinist, technocratic and biased. It has also been criticised as attempting to falsely measure the intangible through fixed lines and points in space, ultimately failing to express the deeper relevancies of place (Ball 2002; Carton & Thissen 2009). Regardless, PGIS remains a popular approach for understanding varied cultural and physical phenomena as they relate to space and place

(Watts 2010; Brown & Kyttä 2014).

In developed nations, it is common for participants to be engaged remotely through mail-out surveys and mapping exercises (Brown 2005; Brown 2006; Brown & Raymond 2006**;** Nielsen-Pincus et al. 2010; Nielsen-Pincus 2011; Raymond & Curtis 2013; Brown & Raymond 2014; Whitehead et al. 2014). Alternative methods include the use of multiple interviews to seek detailed and nuanced spatial and non-spatial information (Kwaku Kyem 2004; Brown and Raymond 2006; Raymond et al. 2009; Bryan et al. 2011; Reyes García et al. 2012). In some cases non-spatial survey data (attitude and group analysis) have been used to supplement or provide spatial data (Brown 2005; Reyes García et al. 2012).

An understanding of personal values cannot be obtained from PGIS. The theory and practice of conceptualising and measuring values is integrated in a wide range of disciplines, including economics, psychology, philosophy, geography and sociology (Ives & Kendal 2014). Attitudes toward place attachment (Gursoy, Jurowski & Uysal 2001; Jorgensen & Stedman 2001; Stedman 2002; Devine-Wright & Howes 2010), development and conservation (Lockwood 1999; Kaltenborn & Bjerke 2001; McFarlane & Boxall 2000; Shrestha & Alavalapati 2006; Clement & Cheng 2011), conservation (Lockwood 1997; De Groot & Steg 2007) and trees (Lockwood 1999; Moyer, Owen & Duinker 2008; Kirkpatrick, Davidson & Daniels 2012, 2013) have been measured. Correlations have been found between attitudes, behaviours, belief systems, identity, attitude to conflict and support for development or conservation in some cases, but not in others.

The spatial analysis phase using GIS almost exclusively involves assigning values to a single grid cell or point (Brody et al. 2004; Kwaku Kyem 2004; Brown 2005; Brown 2006; Brown and Raymond 2006; Nielsen-Pincus et al. 2010; Bryan et al. 2011; Nielsen-Pincus 2011; Raymond & Curtis 2013; Brown & Raymond 2014; Whitehead et al. 2014). This raster approach is restrained by pixel size. Although GIS software has the capacity to create polygons, in a vector approach, the raster approach dominates the literature (Bader and Weibel 1997; Brown 2005; Raymond et al. 2009). A vector approach might be beneficial in face-to-face PGIS (Brown & Pullar 2012) as it may be able to enhance participation and knowledge-sharing (Brown 2005).

There is literature that suggests that PGIS processes have the potential to facilitate compromise between conflicting parties (Allan & Peterson 2002; Kwaku Kyem 2002, 2004; Kyem 2006; Brown & Donovan 2013). Whilst PGIS processes are expensive, they are thought more likely to produce compromise between groups than ordinary mapping methods (Kwaku Kyem 2004; Abdulrahman 2011) as they have the potential to reveal ideologically-based preferences and communicate real life modelling of land use conflicts (Allan & Peterson 2002; Brown, Kelly & Whitall 2013). However, the success of PGIS in enabling compromise has been variable (Janssen, Goosen & Omtzigt 2005). Critics argue that PGIS practices are largely confined to academia and have failed to translate into agency planning (Brown & Reed 2012; Brown & Donovan 2013, 2014) and are unsuitable for assisting conflict management due to the difficult technology (Kyem 2006). PGIS is more likely to succeed where there is genuine engagement and commitment by public agencies to support stakeholder decisions through institutional and socio-political-economic frameworks (Abdulrahman 2011; Brown & Donovan 2013). Early implementation of PGIS may positively influence conflict resolution outcomes if discussion about compromise is stimulated at the beginning of conflict problems (Janssen, Goosen & Omtzigt 2005) and stakeholders are involved in the design of PGIS procedures, particularly relating to land use preferences and conflict maps (Kwaku Kyem 2004; Zhang & Fung 2013). If appropriately planned and supported, PGIS has the potential to create collaborative conditions in which social networks and trust are developed, opening dialogue for future negotiation and compromise (Kwaku Kyem 2004).

An integration of research into attitudes and values, and PGIS processes can provide new insights into spatial and non-spatial factors that influence peoples' preferences (Balram & Dragićević 2005). Whilst attitudes and preferences have been used to inform and create GIS maps / data layers, no reciprocal triangulation between attitudinal syndromes, and PGIS participant spatial preferences can be found.

Strongly held attitudes become fixed in early adulthood, are stable over time and are resistant to change (Ajzen 2001; Hatemi et al. 2009; Wilson & Hodges 2013). However, changes in attitudes can occur in some circumstances (Kollmuss & Agyeman 2002; Petty & Briñol 2010). Processes that expose people to a large amount of accurate and new information have the potential to change attitudes (Davidson 2014). Individuals with weak attitudes require less time to change their attitudes compared to those with strong attitudes (Davidson 2014). The relevance of the information affects its impact and potential to change attitudes. The more relevant the information the more effective it may be in changing attitudes (Pieroo et al. 2004; Bohner, Erb & Siebler 2010). Persuasive communication can influence the level of scrutiny and consideration of information. Petty and Cacioppo (2012) argue that individuals can change their attitude with minimal scrutiny of information based on the attractiveness of the source, or with thoughtful consideration based on the advocacy of the source. Personal attitude traits such as open-/closed-mindedness can influence the likelihood of attitudinal change. Open-minded individuals tend to be receptive to change and process information systematically compared to closed-minded individuals who require less information and are inclined to discount new information (Nisbet et al. 2013). People who are highly ego-involved, able and motivated to participate in debates with others, are likely to hold strong opinions and unlikely to shift their attitudes (Petty & Caccioppo 1990; Wojcieszak 2011).

Group discussion has variable influence on changing individual and collective attitudes during and after deliberation (Black et al. 2011; Wojcieszak 2011). Persuasive group members with strong opinions may unconsciously persuade others (Bowman & Brandenberger 2012; Rafferty, Jimmieson & Armenakis 2013) and reject counter-attitudinal arguments (Wojcieszak 2011). Discussion groups of like-minded peers may lead to confirmation of biases, reinforcement of attitudes and group polarisation (Mercier & Landemore 2012). Alternatively, exposure to counter-views within groups of diverse attitudes may lead to individual polarisation, impede moderation and distort opinions (Wojcieszak 2011). Nonetheless, there is some evidence to suggest that group discussion may improve cooperation, task performance, moderate views and decrease conflict (Barsade 2002; Black et al. 2011; Wojcieszak 2011).

Exposure to information, particularly about emotions and beliefs (Pooley & O'Connor 2000), may enable people to change their attitudes and behaviours toward the environment (Kollmuss & Agyeman 2002), although for large and complex environmental issues such as climate change this generalisation does not necessarily apply (Kellstedt, Jimmieson & Armenakis 2008). The provision or comprehension of objective scientific information does not necessarily influence attitudes toward environmental conflicts, or change polarised views (Corner, Whitmarsh & Xenias 2012; Kahan et al. 2012). Attitude changes are affected by personal conflicts of interest and the cultural lens in which information is framed (Lakoff 2010; Moser & Dilling 2011; Kahan et al. 2012). Face-to-face information sharing has been argued as more effective in changing attitudes than mass media or scientific / technocratic modes (Moser & Dilling 2011).

In this chapter, a novel combination of data on attitudes and PGIS to identify the nature and distribution of conflict in the Tarkine region are used. The hypotheses that: conflict is multidimensional; that informed discussion of values leads to increased willingness to compromise potential outcomes; and, that variation in such willingness is predictable, is tested.

4.3 Methods

4.3.1 Data collection

The recruitment methods, interview procedures and lines of enquiry were approved by the Tasmanian Social Science Human Research Ethics Committee. A desktop media and literature review (November 2011 to December 2012) identified conflicts over the Tarkine, as did the involvement of the author in various advisory bodies relevant to the area. All identified conservation and economic values were assessed for their level of significance or profitability. Their spatial variation was mapped in this thesis (chapters 2 and 3), and areas of potential conflict with different weightings of conflicting values identified (chapter 4).

To test the hypotheses key actors involved in conflict in the Tarkine and those that had a specific interest or agenda in the region were targeted. A target population was identified by using anthropological and ethnographic observations (Bernard 2011; Cook & Crang 1995), a media review (Bryman 2012; Hovatter 1997) and snowballing methods (Coleman 1958-1959; Goodman 1961; Heckathorn 2011). Potential participants were provided with a background paper about the workshop and a link to a website (www.tarkinestudy.com). Participants were recruited from the Tasmanian Aboriginal community (4), conservation NGOs (5), land managers for Parks and Wildlife or NRM (7), the forest industries (5), the mining industry (8), recreationists (5), the tourism industry (6), relevant researchers (5), politicians (1) and conservationists (3). The sample size, response rate and interest group category representation are consistent with accepted cross-cultural sample size and study power standards (Bacchetti et al. 2005; Murdock & White 1969; Schweizer & Lang 1989; Turner 2003).

A pilot workshop involving eight participants from academic, expert and activist backgrounds tested the questionnaire and the workshop format. Specific workshop categories were created: conservation and ecotourism, forestry managers and contractors, miners, land managers, off-road vehicle recreationists and Tasmanian Aborigines. Participants were invited to workshops with people with similar interests in order to have a focus on the process not the political arguments. The conservation and ecotourism workshop had participants from Save the Tarkine, the Tasmanian Wilderness Society, nature photographers and eco-tourism operators. The forestry managers and contractors workshop had Forestry Tasmania office and field staff, and timber harvesting and haulage contractors. The miners workshop had retired miners and community leaders from the Waratah area, a mining town located within the Tarkine. The land-managers workshop had Parks and Wildlife Services office and field staff and Cradle Coast Natural Resource Management staff. The off-road vehicle recreationists workshop had four-wheel-drive club members, enthusiasts and lobbyists. It was decided that Tasmanian Aboriginal people would be interviewed individually, as the workshop format was culturally inappropriate.

At the beginning of the workshop or meeting, participants were asked to complete a questionnaire (Appendix 7.2). Respondents used a seven point Likert scale to rate the importance to them of the Tarkine for the values listed in Table 4-2. Respondents also used this scale to indicate the extent to which they identified personally as a conservationist, a person in favour of economic development or a person in favour of a balance between the two, and how much they considered themselves as activists or lobbyists. These questions were intended to elicit the extreme conservation or development positions, thus reflecting potential conflict scales and philosophical trenches. Participants were asked to draw their favourite places on detailed topographic maps. This spatial exercise sought unbiased place attachments for later comparison to areas selected for development or conservation.

The next stage of the workshop included a three-hour presentation and discussion of mapped natural values (Aboriginal cultural heritage, coastal landforms, biodiversity, rainforest, old growth forest, river landscapes, wilderness and aesthetics) and mapped economic values (carbon, tourism, hydro-electricity, wood and mineral resources) and maps of areas in which conservation or development had higher scores at different weightings of the two integrated sets of values. Conservation biased maps had a conservation weight of 100% and development weights ranging from 1%, 5%, 10%, 30% and 50%. Development biased maps had a development weight of 100% and conservation weights ranging from 1%, 5%, 10%, 30% and 50%. An unbiased map option was provided where an equal weight 100% was given for conservation and development. Participants worked in groups of four discussing important issues relating to the Tarkine, conflicts about the Tarkine, conservation and development map option preferences, and, towards the end of the workshop, whether they had changed their thinking about the Tarkine and the PGIS process generally (Table 4-3). Participants consented to audio recordings being made of the group discussions.

At the end of the workshop, a questionnaire asked participants if they had changed their views on extent of possible development, conservation or compromise and the usefulness of the PGIS process, again using a seven point Likert scale (Likert 1932) (Table 4-2). The final task involved participants drawing important areas for conservation and or development that they would not compromise on a detailed topographic map. The spatial relationships between their preferred map for development or conservation and the areas that they nominated as having no room for compromise were thus determined.

4.3.2 Data analysis

A varimax principal component analysis using a correlation matrix from the questionnaire data was used to indicate the main independent attitudinal continua among the respondents. The input from the questionnaire data was the score on the 7-point Likert scale for the 29 questions with this structure (Table 4-2). Eight factors accounted for most of the variability (Table 4-1). A cluster analysis using Ward's method with Euclidean distance was performed using the scores for the eight factors to generalise differences between individuals. There was a strong rise in the error between seven and six groups, so seven groups were selected. ANOVA with Tukey's post-hoc test (Tukey 1949) was used to determine whether groups differed on each of the factor scores.

A digitised map template was produced, identical to the paper map used by participants. Polygons were created for each individual for favourite places, areas for 'no compromise' for conservation, areas of 'no compromise' for development and areas available for compromise. Areas that were not nominated as 'no compromise' were interpreted as being open to compromise for either development or conservation. The polygons for each individual were overlain for each group. Each of these new polygons was given group values for each of no compromise for conservation, no compromise for development, compromise and favourite place (Table 4-4). These group values were the percentage of the members of the group that labelled the polygon in the particular way (e.g. if two members of a group labelled the polygon 'conservation' and three did not, the value for 'conservation' would be 40%). The classificatory groups generated by the cluster analysis were used instead of the original workshop group classification.

A map for each group was produced that showed those polygons that were agreed by all who drew maps to belong to development or conservation with a score on a conflict intensity index for the remainder. Conflict intensity was calculated by multiplying the percentage scores for agreement for conservation and development (for values greater than zero), then converting these values to a range between 0 and 100 (e.g. as the conflict intensity number increased so did the conflict) (Figure 4.3). The group conflict intensity values were averaged to produce a general map. This procedure was followed to avoid differences in sizes of groups affecting the general map. The above procedure was used for both the selected and the drawn maps.

Areas of potential compromise (drawn maps) were calculated by identifying polygons that had higher total scores for all groups to compromise than total scores for conservation and development combined (Figure 4.4b).

The two spatial data sets (drawn maps and selected maps out of the PGIS set) were then combined to illustrate the maximum potential spatial conflict and the extent of combined group agreement. The combined conflict polygons were assessed for coincidence with the conservation and economic values presented in the workshop and the average group agreement for actions of conserve or develop such values. Each workshop value map that coincided with conflict polygons was selected. A new average group agreement value for 'conserve' or 'develop' was calculated for these polygons using the original selected map group values in ArcGIS. All new average group agreement scores were used to calculate the combined average group agreement across all groups to conserve or develop the workshop map values. The selected map percentage of group agreement was used to calculate average group agreement rather than that of the drawn map, as it yielded a higher response therefore represented the maximum potential of spatial and group conflict.

The eight attitudinal factors identified from the varimax rotated factors loadings for importance and values of the Tarkine (Table 4-1) were used to determine continuous and dichotomised attitudinal differences between individual participants (Figure 4.2).

The matrix plot of attitudinal factors by group (Figure 4.5) used the eight attitudinal factor scores for individuals identified from the varimax rotated factors loadings for importance and values of the Tarkine (Table 4-1). Group placements were compared on the two axes for diverging valuing of attitudinal factors to determine intergroup conflict.

Compromise scores were calculated by comparing areas that individuals chose for conservation or development (selected maps) to areas that they drew as not for compromise for conservation or development. The percentage of the study area that participants selected as not for compromise for conservation in the drawn map was subtracted from the percentage of the study area that was assigned for conservation in the selected map. This difference indicated the percentage of the study area that the participant was willing to compromise for conservation values (conservation compromise score). The same equation was conducted for compromise for development (development compromise score). Positive compromise scores indicated a willingness to compromise spatially. Negative compromise scores indicated a non-compromise attitude and entrenching of spatial preferences. The conservation and development compromise scores were summed to reflect the overall spatial willingness of each participant to compromise (compromise score).

General linear modelling or multiple regression was used in Minitab16 (Ryan, Ryan & Joiner 1972) to derive a model that made the greatest theoretical sense of the relationships between non-spatial and spatial data. All variables were tested in the models (the input from the 7-point Likert scale questionnaire data, the scores for the three most important personal issues relating to the Tarkine and why places are favoured, mapping choices and demographic information). The maximum number of variables used in any selected model was two because of the small size of *N* (Figure 4.6).

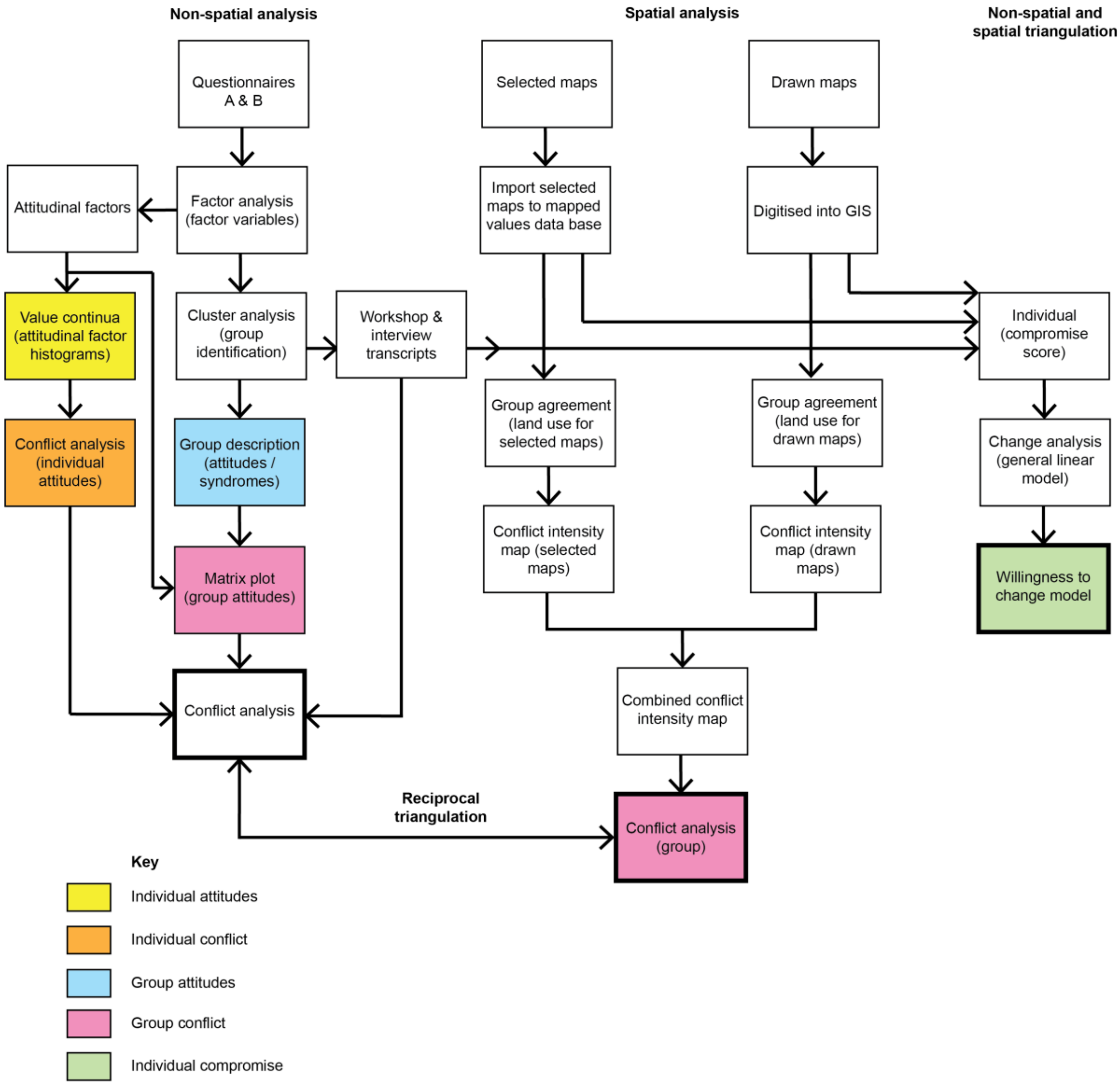

Figure 4.1 – Data analysis procedure.

4.4 Results

4.4.1 Attitudinal factors

The ‘nature’ factor was the strongest (Table 4-1, Figure 4.2). It involved both anthropocentric and biocentric valuing of nature in which people were either nature lovers or not nature lovers. The nature factor had high positive loadings on the importance of the area for scenery, wilderness, clean air and water, wildlife and wilderness. Those who loved nature valued the importance of the Tarkine to the Tasmanian community for its ecosystem services and to a lesser extent, the personal enjoyment that they derived through sharing and relaxing in natural environments with family and friends and knowing that it is there for nature. Fewer people scored low on this factor than high (Figure 4.2).

The ‘development’ factor expressed a continuum from those who valued economic benefits and employment opportunities, both for the wider Tasmanian population and themselves (development lover) to those who did not (development disliker). This factor loaded positively on statements valuing economic development and employment with a weaker positive skew in scores than the first axis.

The ‘social’ factor was a continuum in social relationships from those that enjoyed partying with others (party animals) to those with who preferred to socialise with family whilst recreating. This factor was distinct from the nature factor in that the focus was on the personal value of socialising and recreation whilst being in nature. This factor loaded positively on the value of drinking and partying with friends, and negatively on values related to being in nature with family. The partygoers were few.

The ‘ORV’ (off-road vehicle recreation) factor reflected the perceived importance of off-road vehicle recreation at the Tasmanian and personal level. The ORV factor revealed an opposition in the data between those who identified as conservationists, and recognised the importance of Aboriginal heritage, and off-road vehicle drivers. The ‘ORV’ factor was negatively loaded on statements related to the value of off-road driving recreation and European heritage and positively loaded on conservation and Aboriginal heritage. The distribution of scores on this factor was almost normal.

Activist and lobbyist behaviours coupled with a high level of personal identification as a conservationist were the defining features of one extreme of the ‘activist’ factor. At the other extreme were people who believed in a balanced between conservation and development.

The activist factor was heavily positively loaded on personal identification as a conservationist, activist and lobbyist and negatively loaded on identification as a compromiser between conservation and development. There was a negative skew in the scores.

The ‘hunting’ factor related to a narrow set of personal factors about provision of places for hunting and connecting with European heritage whilst partying away from others. This factor was heavily negatively loaded on the personal importance of hunting, European heritage and drinking and partying with friends. There were few people with low scores and these were separated from the main mass of the respondents.

The ‘fishing’ factor was strongly negatively loaded on the personal importance of fishing, personal identification as a traditional recreationalist and someone who liked to balance development and conservation. There were positive loadings on the personal importance of employment and knowing that the Tarkine was there for nature. The scores were approximately normal in distribution.

The Aboriginal factor was positively loaded on the Tasmanian importance of the area for Aboriginal heritage and outdoor recreational activities, and the perception of respondents of their knowledge of the area. The scores were close to a normal distribution.

Table 4-1 – Attitudinal factors.

(Attitudinal factors, showing varimax rotated factor loadings and communalities for importance and values of the Tarkine).

	Factor[i]								C[ii]
	1	2	3	4	5	6	7	8	
Variable									
General knowledge of the Tarkine	0.039	0.195	**-0.519**	0.252	0.146	0.082	0.046	**0.599**	0.822
<u>*Personal importance of the Tarkine*</u>									
Off-road vehicle driving and riding	0.42	-0.000	-0.134	***-0.788***	0.038	-0.154	-0.92	-0.220	0.878
Hiking and walking	0.172	0.090	***-0.875***	0.076	0.035	-0.002	-0.123	0.166	0.873
Being and sharing with family / friends	**0.348**	0.224	***-0.735***	-0.208	0.200	0.094	-0.164	-0.084	0.870
Fishing	0.006	0.173	-0.168	-0.162	-0.098	-0.287	**-0.835**	0.079	0.890
Commercial / economic / employment	-0.120	**0.564**	-0.210	-0.066	-0.179	-0.259	**0.485**	-0.090	0.810
Resting, relaxing, contemplation	**0.593**	0.087	***-0.594***	-0.100	0.188	0.012	0.033	0.102	0.875

i) Variables that are influencing factors in each column are shown bold (>0.3) and bold and italic (<-0.3). Attitudinal factors: 1= nature, 2 = development, 3 = social, 4 = off-road vehicle recreation (ORV), 5 = conservation activism, 6 = hunting, 7 = fishing and 8 = Aboriginal. *ii*) Communality.

	Factor[i]								C[ii]
	1	2	3	4	5	6	7	8	
Variable									
Connecting with European heritage	-0.003	0.205	-0.111	**-0.318**	0.164	**-0.688**	-0.237	0.224	0.783
Hunting	0.107	0.036	0.025	0.007	-0.085	**-0.901**	-0.090	-0.090	0.852
It's good to know it's there for nature	**0.607**	-0.023	**-0.325**	0.077	0.029	-0.193	**0.458**	-0.039	0.857
Drink and party away from others	0.013	0.029	**0.487**	-0.154	-0.019	**-0.659**	-0.073	0.132	0.820
Tasmanian importance of the Tarkine									
Habitat for plants and animals	**0.797**	-0.135	-0.045	0.120	-0.068	-0.215	0.082	0.171	0.793
Aboriginal cultural heritage	0.269	-0.123	-0.062	**0.457**	0.022	-0.233	0.119	**0.690**	0.857
Providing economic benefits	0.043	**0.955**	0.005	0.054	0.000	-0.078	0.058	0.044	0.936
Fishing, surfing, canoeing, hiking	0.164	**0.751**	-0.189	-0.192	-0.006	0.195	-0.051	**0.367**	0.891
Scenic landscape	**0.857**	0.206	-0.058	0.043	0.115	0.113	-0.079	-0.106	0.848
Employment opportunities	0.110	**0.928**	-0.051	0.012	0.037	-0.028	-0.008	0.053	0.898
Providing clean water and air	**0.824**	0.122	-0.079	-0.035	0.106	-0.145	0.010	0.059	0.755

i) Variables that are influencing factors in each column are shown bold (>0.3) and bold and italic (<-0.3). Attitudinal factors: 1= nature, 2 = development, 3 = social, 4 = off-road vehicle recreation (ORV), 5 = conservation activism, 6 = hunting, 7 = fishing and 8 = Aboriginal. *ii*) Communality.

		Factor[i]								C[ii]
		1	2	3	4	5	6	7	8	
Variable										
Enhancing environmental awareness and knowledge		**0.802**	0.165	**-0.307**	-0.025	0.152	-0.114	-0.006	0.154	0.858
Wilderness		**0.829**	-0.008	-0.049	0.030	-0.023	0.157	-0.011	-0.024	0.731
Off-road vehicle driving and riding		-0.132	0.125	0.083	**-0.888**	-0.102	0.025	0.046	0.041	0.844
Providing carbon storage in its forests		**0.582**	0.246	0.021	-0.159	0.131	0.014	-0.125	0.102	0.863
Personal identification										
Conservationist	-0.012	-0.163	-0.249	**0.308**	**0.598**	0.217	0.252	-0.255	0.842	
In favour of economic development	0.122	**0.847**	-0.064	-0.047	-0.022	-0.127	-0.184	-0.214	0.837	
A person who enjoys nature	0.269	0.055	-0.193	0.143	0.149	0.030	-0.054	0.012	0.907	
In favour of balance between										
conservation and development	0.031	**0.543**	-0.203	-0.078	**-0.489**	-0.030	**-0.372**	-0.021	0.726	
An activist	0.150	0.037	-0.162	0.057	**0.890**	0.079	0.177	-0.023	0.907	

i) Variables that are influencing factors in each column are shown bold (>0.3) and bold and italic (<-0.3). Attitudinal factors: 1= nature, 2 = development, 3 = social, 4 = off-road vehicle recreation (ORV), 5 = conservation activism, 6 = hunting, 7 = fishing and 8 = Aboriginal. *ii*) Communality.

		Factor^{i}								C^{ii}
Variable		1	2	3	4	5	6	7	8	
Traditional recreationist (enjoys off-road driving, fishing and hunting)	0.111	-0.097	-0.001	**-0.747**	-0.088	-0.260	**-0.313**	-0.214	0.804	
A lobbyist	0.127	-0.022	-0.050	-0.011	**0.862**	-0.133	-0.144	0.169	0.858	
Variance	4.887	4.080	2.705	2.671	2.421	2.319	1.706	1.427	24.482	
% variance	0.169	0.141	0.093	0.092	0.083	0.080	0.059	0.049	0.844	

i) Variables that are influencing factors in each column are shown bold (>0.3) and bold and italic (<-0.3). Attitudinal factors: 1= nature, 2 = development, 3 = social, 4 = off-road vehicle recreation (ORV), 5 = conservation activism, 6 = hunting, 7 = fishing and 8 = Aboriginal. *ii*) Communality.

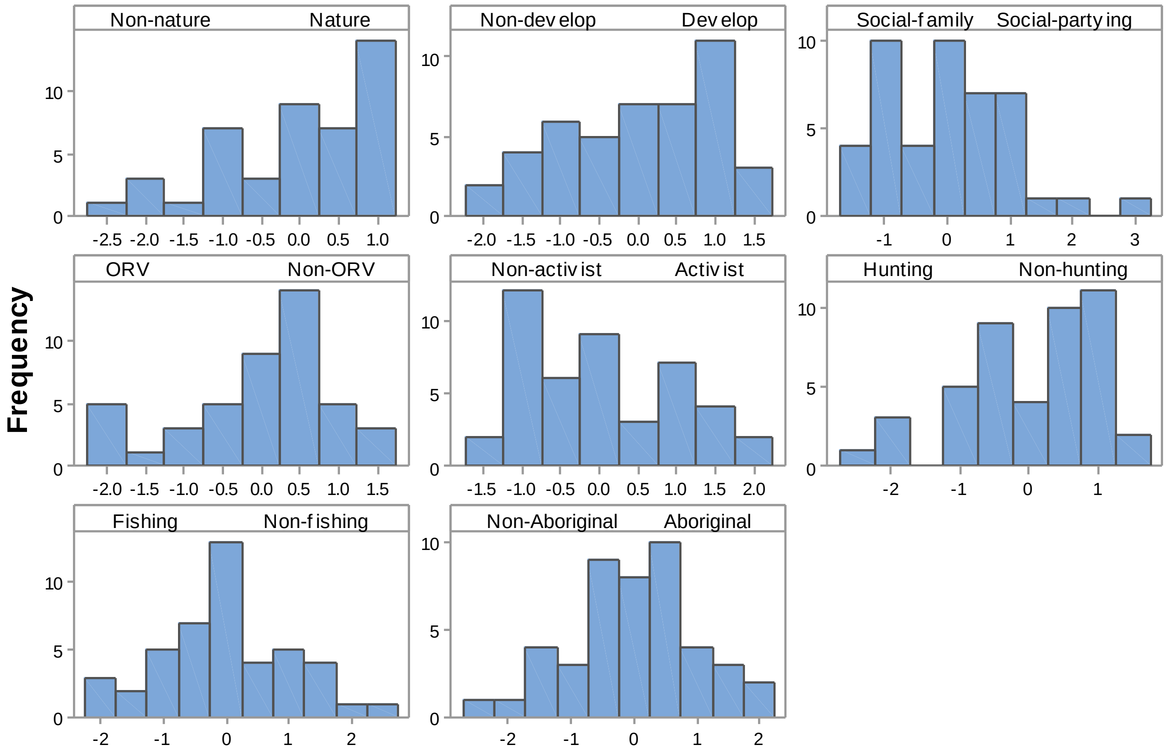

Figure 4.2 – Histogram of attitudinal factor scores by individuals.

(Nature factor = non-nature / nature histogram, development factor = non-develop / develop histogram, social factor = social-family / social-partying histogram, off-road vehicle recreation factor = ORV / Non-ORV histogram, activist factor = Non-activist / Activist histogram, hunting factor = non-hunting / hunting histogram, fishing factor = non-fishing / fishing histogram and Aboriginal factor = Aboriginal / non-Aboriginal histogram).

4.4.2 Attitude syndromes

Seven groups were selected. Each group was distinct from each other group on at least one factor at $P < 0.05$. Groups 3 and 4 differed the most and groups 2 and 7 were most similar (Table 4-2 and Table 4-3). Group 1 consisted of 'nature conservationists'; this group included people who strongly identified themselves as conservationists with an activist and lobbyist agenda and who were involved in organisations with a conservation interest in the Tarkine. They highly valued the Tarkine as a place to rest, relax and take time out to contemplate, with the river environs being greatly favoured. They perceived the Tarkine as being very important to the Tasmanian community for soft recreational opportunities (fishing, surfing, canoeing and hiking) and were concerned about negative outcomes for conservation management. Along with Groups 2 and 3, they placed very high personal importance on being able to connect with Aboriginal cultural heritage on the coast. Their strong attachment to natural values was reflected by the fact that all had mapped areas in which they would not compromise conservation values. All nature conservationists that chose a map that reflected their view selected the most extreme conservation map option available (development 1% and conservation 100%).

Group 2 were 'soft naturalists' who were reassured by knowing that the Tarkine is there for nature. They placed high personal value on opportunities to go hiking and walking in the Tarkine and favoured locales where they could connect with flora, fauna and natural values. They felt that the Tarkine was very important to the Tasmanian community for its habitat for plants and animals as well as its scenic landscapes. Aboriginal cultural heritage was a significant value for favourite places, of very high importance personally and to the Tasmanian community as a whole. They found the mapping process useful in helping them understand values that they would not compromise, with all selecting a conservation orientation with a development weight ranging between 1% and 100%. Twenty seven percent of the soft naturalists chose conservation orientated maps that had 10% development weight. Eighteen percent selected conservation orientated maps that had 1%, 30% and 50% development weight and 9% chose conservation orientated maps that had 5% and 100% development weight.

Group 3 were 'balanced developers' who favoured areas of the Tarkine where they had work connections and placed high personal importance on the direct economic and employment opportunities that the natural resources could provide to them. They strongly identified themselves as people who favoured economic development and believed that the Tarkine represented a significant asset for providing employment and economic benefits to the Tasmanian community. Although development values were important to them, they placed equal importance on the benefits that the Tarkine provides for the Tasmanian community in its contribution to the enhancement of environmental awareness and knowledge and its provision of carbon storage. They had a recreational aspect to their value set, in which fishing, hunting and camping scored highly. They scored highly for connection to both Aboriginal cultural heritage and European heritage. The Tarkine also represented an important place where they could drink and party away from others. They found the mapping process very useful for understanding the importance of the Tarkine, with most selecting a development weighted map with a conservation weight ranging between 1% and 100%.%. Forty percent of the balanced developers chose development orientated maps that had 50% conservation weight and 20% selected development orientated maps that had 1% and 100% conservation weight.

Group 4 were ‘biocentrics’ who were primarily concerned with the management of biodiversity values in the Tarkine. The need for greater protection of Aboriginal cultural heritage and concerns about threats to the intactness, naturalness and wilderness values of the landscape were key issues. Commercial, economic and employment benefits were not personally important and they perceived such values as only slightly important for the Tasmanian community. They were least interested of all groups in values associated with camping, hiking, walking, sharing places with family or friends, resting, and relaxing. This attitude extended to how they viewed the importance of the Tarkine to Tasmania as a whole, where they scored lowest for recreational and economic values. They placed minimal significance on anthropogenic values and least identified themselves as people who gave value to economic development or balance between conservation and development. They were neutral about the mapping process, which had little impact on changing their thinking. Only one third of this group chose a map, all choosing the same highest conservation weighted map option available (development 1% and conservation 100%).

Group 5 were ‘quiet compromisers’ who indicated that they were more open to compromise than other groups. They changed their thinking more than others on how much of the Tarkine could be developed or conserved and their thoughts about conflict. They were least likely to identify themselves as activists or lobbyists and like the soft naturalists and balanced developers found themselves sympathising with the need for a balance between conservation and development. Access to forestry and mining resources for employment purposes was an issue as two thirds were employed by a business with interests in the

Tarkine. Recreation activities were not important to them, although they believed that any recreation activity needed to be responsible and not cause damage to natural values. There was a quiet and reflective aspect to this group, with wilderness values being seen as important to the Tasmanian community at the same level as for nature conservationists. Wilderness and spiritual values, quietness, home locales and the energy of the wild weather were key elements that allowed them to connect with their favourite places. The map choices of this group were wide ranging across both development and conservation spectra, with a lowest conservation weight of 1% and lowest development weight of 30%.

Group 6 were ‘developers’ who identified strongly as people who favoured a balance between conservation and development. Although they were concerned about issues relating to planned, balanced and sustainable development, half chose the most extreme development map (100% development and 1% conservation). All were employed by a business with interests in the Tarkine and were most interested in nominating areas that they would not compromise for development. They were concerned about restrictions on recreation access, but were indifferent about off-road vehicle recreation activities. They gave least personal importance to Aboriginal cultural heritage and intrinsic natural values, and gave the lowest rating to the Tarkine’s importance to the Tasmanian community for enhancing environmental awareness and knowledge. Even though scenic values and fishing activity were important features that influenced their favourite places, they seemed less interested in the natural values than the balanced developers.

Group 7 were ‘Off-roaders’ who were focussed on their primary need to drive off-road vehicles whilst sharing their exploration experiences with family and friends. They saw themselves as traditional recreationists who enjoy fishing and hunting and believe that the Tarkine is very important to the Tasmanian community for off-road vehicle driving and riding. Ongoing access to off-road tracks where they could explore coastal values was a substantial concern for this group. This was evidenced by the fact that they were the most active in community consultations and forums relating to the Tarkine. They chose maps that ranged across the spectrum but predominantly conservation weighted, with the lowest conservation weight of 50% (map E) to the lowest conservation weight of 1% (map K).

Table 4-2 – Mean score for the importance of values.

(Mean score for the importance and values of the Tarkine and percentage frequency for responses of attitude groups).

	Group[ii]							*P*	%[iii]
	1	2	3	4	5	6	7		
N	5	11	5	6	5	6	7		
General knowledge of the Tarkine	**5.20**	4.63	4.40	2.83	3.20	3.33	4.14	0.052	100.00
<u>*Three most important personal issues*</u>									
Conservation management	**4.60**	2.45	1.00	2.00	1.00	2.33	3.57	0.170	28.89
No new mines / limit mines	**1.80**	1.36	1.00	1.00	1.00	1.00	1.00	0.614	4.44
Community education about values	**1.40**	1.00	1.00	2.33	1.00	1.00	1.28	0.187	8.89
Rainforest and forest conservation	**1.40**	1.00	1.00	1.33	1.00	1.00	1.00	0.393	4.44
Scenic management	**1.40**	1.00	1.00	1.33	1.00	1.00	1.28	0.586	6.67

i) Seven point Likert scale: 1 = not important, 2 = slightly important, 3 = somewhat important, 4 = moderately important, 5 = considerably important, 6 = very important and 7 = extremely important. *ii)*. Group 1 = nature conservationists, Group 2 = soft naturalists, Group 3 = balanced developers, Group 4 = biocentrics, Group 5 = quiet compromisers, Group 6 = developers and Group 7 = off-roaders. Higher values in each row are shown in bold, lowest values in each row are shown in bold and italic (where P <0.005) and italic (where P >0.005). *iii)* Total percentage of respondents who answered each question. *iv)* Indicates the mean group percentage for the area of the Tarkine that respondents mapped for compromise and no compromise.

	Group[ii]							*P*	%[iii]
	1	2	3	4	5	6	7		
N	5	11	5	6	5	6	7		
Habitat protection	1.40	**2.27**	1.00	1.00	1.00	1.00	1.57	0.362	11.11
Conflict resolution needed	1.00	**1.90**	1.00	1.00	1.00	1.00	1.00	0.305	6.67
Impact of extractive activities	1.00	**1.72**	1.00	1.66	1.00	1.00	1.00	0.648	6.67
Visitor access / infrastructure	1.00	**1.54**	1.00	1.00	1.00	1.33	1.00	0.580	8.89
Specialness of place	1.00	**1.54**	1.00	1.00	1.00	1.00	1.00	0.820	2.22
Conflict and uncertainty	1.00	**1.54**	1.00	1.00	1.00	1.00	1.00	0.820	2.22
Boundary argument	1.00	**1.54**	1.00	1.00	1.00	1.00	1.00	0.820	2.22
Positive lifestyle	1.00	*1.00*	**3.40**	1.00	2.20	1.00	1.00	**0.037**	6.67
Positive community spirit	1.00	*1.00*	**2.60**	1.00	1.80	1.00	1.00	**0.037**	6.67

i) Seven point Likert scale: 1 = not important, 2 = slightly important, 3 = somewhat important, 4 = moderately important, 5 = considerably important, 6 = very important and 7 = extremely important. *ii)*. Group 1 = nature conservationists, Group 2 = soft naturalists, Group 3 = balanced developers, Group 4 = biocentrics, Group 5 = quiet compromisers, Group 6 = developers and Group 7 = off-roaders. Higher values in each row are shown in bold, lowest values in each row are shown in bold and italic (where P <0.005) and italic (where P >0.005). *iii)* Total percentage of respondents who answered each question. *iv)* Indicates the mean group percentage for the area of the Tarkine that respondents mapped for compromise and no compromise.

	Group[ii]							*P*	%[iii]
	1	2	3	4	5	6	7		
N	5	11	5	6	5	6	7		
Perception of being pristine	1.00	1.00	**2.20**	1.00	1.00	1.66	1.00	0.354	4.44
Sustainable use	1.40	1.18	**2.20**	1.00	1.00	1.00	1.00	0.385	6.67
Manage for multiple use	1.00	1.00	**1.80**	1.00	1.40	1.00	1.00	0.296	4.44
Sharing Aboriginal knowledge and access to Country	1.00	1.18	**1.80**	1.00	1.00	1.00	1.00	0.400	4.44
Biodiversity management	1.00	1.00	1.00	**4.00**	1.40	1.00	1.00	**<0.001**	11.11
Aboriginal heritage protection	3.40	2.19	2.20	**3.66**	2.20	1.00	1.28	0.224	28.89
Maintain intactness, wilderness and naturalness	3.00	2.27	1.00	**3.33**	1.80	1.00	1.00	0.180	20.00
Development and over development	1.00	1.18	1.00	**1.33**	1.00	1.00	1.00	0.718	4.44
Responsible recreation	1.00	1.54	1.00	1.00	**3.00**	1.00	1.85	0.238	11.11

i) Seven point Likert scale: 1 = not important, 2 = slightly important, 3 = somewhat important, 4 = moderately important, 5 = considerably important, 6 = very important and 7 = extremely important. *ii)*. Group 1 = nature conservationists, Group 2 = soft naturalists, Group 3 = balanced developers, Group 4 = biocentrics, Group 5 = quiet compromisers, Group 6 = developers and Group 7 = off-roaders. Higher values in each row are shown in bold, lowest values in each row are shown in bold and italic (where P <0.005) and italic (where P >0.005). *iii)* Total percentage of respondents who answered each question. *iv)* Indicates the mean group percentage for the area of the Tarkine that respondents mapped for compromise and no compromise.

	Group[ii]							*P*	%[iii]
	1	2	3	4	5	6	7		
N	5	11	5	6	5	6	7		
Forestry / mining access	1.00	1.00	1.00	1.00	**2.20**	2.00	1.00	0.393	4.44
Recreation access	1.00	1.00	1.00	1.00	1.80	**5.33**	1.85	**<0.001**	15.56
Balanced use / development	1.00	1.18	1.00	1.00	1.00	**2.00**	1.00	0.484	4.44
Sustainable tourism development	1.00	1.54	1.80	1.00	1.00	**2.00**	1.00	0.635	8.89
Planned economic development	1.00	1.00	1.00	1.00	1.00	**1.66**	1.00	0.382	2.22
Manage for community benefit / future	1.00	1.00	1.00	1.00	1.40	**1.66**	1.00	0.426	4.44
Sensitive resource access	1.00	1.00	1.00	1.00	1.00	**1.33**	1.00	0.382	2.22
Off-road vehicle access	1.00	1.00	1.00	1.00	1.00	1.00	**4.43**	**<0.001**	8.89
Surfing / fishing beach access	1.00	1.00	1.00	1.00	1.00	1.00	**2.14**	0.071	4.44

i) Seven point Likert scale: 1 = not important, 2 = slightly important, 3 = somewhat important, 4 = moderately important, 5 = considerably important, 6 = very important and 7 = extremely important. *ii)*. Group 1 = nature conservationists, Group 2 = soft naturalists, Group 3 = balanced developers, Group 4 = biocentrics, Group 5 = quiet compromisers, Group 6 = developers and Group 7 = off-roaders. Higher values in each row are shown in bold, lowest values in each row are shown in bold and italic (where P <0.005) and italic (where P >0.005). *iii)* Total percentage of respondents who answered each question. *iv)* Indicates the mean group percentage for the area of the Tarkine that respondents mapped for compromise and no compromise.

	Group[ii]							*P*	%[iii]
	1	2	3	4	5	6	7		
N	5	11	5	6	5	6	7		
Why places are favoured									
Rainforest / forest values	**4.60**	2.63	1.00	3.00	1.00	1.00	1.85	0.115	20.00
River values	**3.40**	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	**0.005**	4.44
Aboriginal cultural values	2.20	**4.27**	2.20	3.00	1.00	1.00	1.85	0.138	24.44
Nature values	1.00	**3.18**	1.00	2.00	1.00	2.00	2.71	0.408	17.78
Flora / fauna values	1.00	**2.63**	1.00	3.00	1.00	1.00	1.85	0.328	13.33
Walking	1.00	**2.09**	1.00	1.00	1.00	2.00	1.85	0.725	8.89
Work	*1.00*	*1.00*	**3.40**	*1.00*	*1.00*	*1.00*	*1.00*	**0.005**	4.44
Waratah town	1.00	1.00	**2.20**	1.00	1.00	1.00	1.00	0.237	2.22

i) Seven point Likert scale: 1 = not important, 2 = slightly important, 3 = somewhat important, 4 = moderately important, 5 = considerably important, 6 = very important and 7 = extremely important. *ii)*. Group 1 = nature conservationists, Group 2 = soft naturalists, Group 3 = balanced developers, Group 4 = biocentrics, Group 5 = quiet compromisers, Group 6 = developers and Group 7 = off-roaders. Higher values in each row are shown in bold, lowest values in each row are shown in bold and italic (where P <0.005) and italic (where P >0.005). *iii)* Total percentage of respondents who answered each question. *iv)* Indicates the mean group percentage for the area of the Tarkine that respondents mapped for compromise and no compromise.

	Group[ii]							*P*	%[iii]
	1	2	3	4	5	6	7		
N	5	11	5	6	5	6	7		
Family times	1.00	1.54	**2.20**	1.00	1.00	1.00	1.85	0.746	6.67
Mix of landscape	1.00	*1.00*	1.00	**3.00**	1.00	1.00	*1.00*	**0.026**	4.44
Spiritual values	1.00	1.00	1.00	1.00	**2.20**	1.00	1.00	0.237	2.22
Quiet place to live / home	1.00	1.00	1.00	1.00	**2.20**	1.00	1.85	0.458	4.44
Wild weather	1.00	1.54	1.00	1.00	**2.20**	1.00	1.00	0.614	4.44
Wilderness	1.00	2.09	1.00	2.00	**2.20**	1.00	1.00	0.631	8.89
Fishing	1.00	1.54	1.00	1.00	**2.20**	1.00	1.85	0.746	4.44
Scenic values	2.20	3.72	1.00	2.00	2.20	**4.00**	3.57	0.465	31.11
Fishing and hunting	1.00	2.09	2.20	1.00	1.00	**3.00**	1.85	0.587	13.33

i) Seven point Likert scale: 1 = not important, 2 = slightly important, 3 = somewhat important, 4 = moderately important, 5 = considerably important, 6 = very important and 7 = extremely important. *ii)*. Group 1 = nature conservationists, Group 2 = soft naturalists, Group 3 = balanced developers, Group 4 = biocentrics, Group 5 = quiet compromisers, Group 6 = developers and Group 7 = off-roaders. Higher values in each row are shown in bold, lowest values in each row are shown in bold and italic (where P <0.005) and italic (where P >0.005). *iii)* Total percentage of respondents who answered each question. *iv)* Indicates the mean group percentage for the area of the Tarkine that respondents mapped for compromise and no compromise.

	Group[ii]							*P*	%[iii]
	1	2	3	4	5	6	7		
N	5	11	5	6	5	6	7		
Mountain values	1.00	1.00	1.00	1.00	1.00	**2.00**	1.00	0.382	2.22
Mix of industry and nature	1.00	1.00	1.00	1.00	1.00	**2.00**	1.00	0.382	2.22
No people	1.00	1.00	1.00	1.00	1.00	**2.00**	1.85	0.557	4.44
Exploring opportunities	1.00	2.63	1.00	1.00	1.00	1.00	**3.57**	0.073	13.33
Coastal values	2.20	2.09	2.20	3.00	2.20	1.00	**3.57**	0.713	22.22
Off-road vehicle opportunities	1.00	1.00	1.00	1.00	1.00	1.00	**1.85**	0.551	2.22
Personal importance of the Tarkine									
Resting, relaxing, contemplation	**6.60**	6.36	6.00	3.66	4.80	4.00	6.42	**<0.001**	100.00
Connecting with Aboriginal heritage	**6.00**	**6.00**	**6.00**	3.00	3.80	2.66	4.28	**<0.001**	82.22

i) Seven point Likert scale: 1 = not important, 2 = slightly important, 3 = somewhat important, 4 = moderately important, 5 = considerably important, 6 = very important and 7 = extremely important. *ii)*. Group 1 = nature conservationists, Group 2 = soft naturalists, Group 3 = balanced developers, Group 4 = biocentrics, Group 5 = quiet compromisers, Group 6 = developers and Group 7 = off-roaders. Higher values in each row are shown in bold, lowest values in each row are shown in bold and italic (where P <0.005) and italic (where P >0.005). *iii)* Total percentage of respondents who answered each question. *iv)* Indicates the mean group percentage for the area of the Tarkine that respondents mapped for compromise and no compromise.

	Group[ii]							*P*	%[iii]
	1	2	3	4	5	6	7		
N	5	11	5	6	5	6	7		
It's good to know it's there for nature	6.80	**6.81**	6.20	5.66	6.80	4.83	6.28	<**0.001**	100.00
Hiking and walking	6.40	**6.54**	5.60	3.00	3.60	3.66	5.71	<**0.001**	84.44
Commercial / economic / employment	2.00	3.90	**6.40**	1.16	2.60	5.16	3.00	<**0.001**	100.00
Fishing	2.20	4.36	**6.20**	3.00	2.00	5.16	4.85	<**0.001**	82.22
Hunting	1.00	2.45	**6.20**	3.00	2.60	1.33	1.42	<**0.001**	82.22
Camping	5.60	4.36	**6.20**	3.00	3.00	4.16	5.57	**0.003**	82.22
Connecting with European heritage	***2.00***	2.81	**5.80**	3.00	2.20	2.00	3.42	**0.001**	82.22
Drink and party away from others	***1.00***	1.45	**4.20**	3.00	2.00	1.50	1.71	<**0.001**	80.00
Being and sharing with family / friends	6.40	6.18	6.20	3.00	4.40	5.16	**6.57**	<**0.001**	100.00

i) Seven point Likert scale: 1 = not important, 2 = slightly important, 3 = somewhat important, 4 = moderately important, 5 = considerably important, 6 = very important and 7 = extremely important. *ii)*. Group 1 = nature conservationists, Group 2 = soft naturalists, Group 3 = balanced developers, Group 4 = biocentrics, Group 5 = quiet compromisers, Group 6 = developers and Group 7 = off-roaders. Higher values in each row are shown in bold, lowest values in each row are shown in bold and italic (where P <0.005) and italic (where P >0.005). *iii)* Total percentage of respondents who answered each question. *iv)* Indicates the mean group percentage for the area of the Tarkine that respondents mapped for compromise and no compromise.

	Group[ii]							*P*	%[iii]
	1	2	3	4	5	6	7		
N	5	11	5	6	5	6	7		
Exploring	6.00	5.81	6.25	4.83	5.20	*4.33*	**6.42**	0.082	97.77
Off-road vehicle driving and riding	***1.20***	1.81	3.80	2.16	3.20	2.83	**5.28**	**0.003**	82.22
<u>*Tasmanian importance of the Tarkine*</u>									
Fishing, surfing, canoeing, hiking	**6.60**	5.00	6.40	3.00	5.40	5.83	5.71	**<0.001**	82.22
Wilderness	**6.40**	6.36	5.60	*4.66*	**6.40**	5.16	5.85	0.189	95.55
Habitat for plants and animals	6.00	**6.63**	6.40	5.83	6.40	*5.00*	6.28	0.134	100.00
Scenic landscape	6.40	**6.45**	6.40	*5.00*	6.40	6.00	5.85	0.261	100.00
Aboriginal cultural heritage	5.80	**6.36**	5.80	5.83	5.00	*4.00*	4.71	0.161	100.00
Employment opportunities	6.60	4.27	**6.80**	2.33	5.60	5.00	3.85	**<0.001**	97.77

i) Seven point Likert scale: 1 = not important, 2 = slightly important, 3 = somewhat important, 4 = moderately important, 5 = considerably important, 6 = very important and 7 = extremely important. *ii)*. Group 1 = nature conservationists, Group 2 = soft naturalists, Group 3 = balanced developers, Group 4 = biocentrics, Group 5 = quiet compromisers, Group 6 = developers and Group 7 = off-roaders. Higher values in each row are shown in bold, lowest values in each row are shown in bold and italic (where P <0.005) and italic (where P >0.005). *iii)* Total percentage of respondents who answered each question. *iv)* Indicates the mean group percentage for the area of the Tarkine that respondents mapped for compromise and no compromise.

	Group[ii]							*P*	%[iii]
	1	2	3	4	5	6	7		
N	5	11	5	6	5	6	7		
Enhancing environmental awareness and knowledge	6.00	6.36	**6.80**	4.66	5.80	4.33	6.28	**0.009**	97.77
Providing clean water and air	5.80	6.27	**6.80**	5.00	6.60	*4.33*	6.28	0.051	100.00
Providing economic benefits	6.20	4.36	**6.80**	2.83	5.60	5.16	3.42	**<0.001**	97.77
Providing carbon storage in its forests	5.80	4.54	**6.40**	3.00	5.60	4.66	6.00	**0.010**	82.22
Off-road vehicle driving and riding	1.80	2.54	4.40	3.00	5.00	4.33	**5.85**	**<0.001**	82.22
<u>Personal identification</u>									
Conservationist	**7.00**	5.45	4.40	5.66	4.60	4.50	5.14	**0.014**	100.00
A person who enjoys nature	**6.80**	6.72	6.60	6.00	*5.60*	6.16	6.28	0.231	100.00
An activist	**6.20**	2.90	4.00	3.66	1.80	1.83	4.28	**0.001**	100.00

i) Seven point Likert scale: 1 = not important, 2 = slightly important, 3 = somewhat important, 4 = moderately important, 5 = considerably important, 6 = very important and 7 = extremely important. *ii)*. Group 1 = nature conservationists, Group 2 = soft naturalists, Group 3 = balanced developers, Group 4 = biocentrics, Group 5 = quiet compromisers, Group 6 = developers and Group 7 = off-roaders. Higher values in each row are shown in bold, lowest values in each row are shown in bold and italic (where P <0.005) and italic (where P >0.005). *iii)* Total percentage of respondents who answered each question. *iv)* Indicates the mean group percentage for the area of the Tarkine that respondents mapped for compromise and no compromise.

	Group[ii]							*P*	%[iii]
	1	2	3	4	5	6	7		
N	5	11	5	6	5	6	7		
A lobbyist	**5.20**	2.00	4.40	3.83	1.20	2.00	4.14	**0.002**	100.00
In favour of economic development	5.00	4.27	**6.40**	2.50	4.60	5.50	3.85	**<0.001**	100.00
In favour of balance between conservation and development	4.00	6.00	6.60	2.66	6.00	**6.83**	5.00	**<0.001**	100.00
Traditional recreationist (enjoys off -road driving, fishing and hunting)	1.00	2.63	4.60	3.00	3.20	3.83	**6.14**	**<0.001**	100.00
Community involvement in forums / consultation related to the Tarkine	3.40	3.27	3.80	3.00	2.40	*2.33*	**4.42**	0.640	100.00

i) Seven point Likert scale: 1 = not important, 2 = slightly important, 3 = somewhat important, 4 = moderately important, 5 = considerably important, 6 = very important and 7 = extremely important. *ii)*. Group 1 = nature conservationists, Group 2 = soft naturalists, Group 3 = balanced developers, Group 4 = biocentrics, Group 5 = quiet compromisers, Group 6 = developers and Group 7 = off-roaders. Higher values in each row are shown in bold, lowest values in each row are shown in bold and italic (where P <0.005) and italic (where P >0.005). *iii)* Total percentage of respondents who answered each question. *iv)* Indicates the mean group percentage for the area of the Tarkine that respondents mapped for compromise and no compromise.

	Group[ii]							*P*	%[iii]
	1	2	3	4	5	6	7		
N	5	11	5	6	5	6	7		
Changed their thinking									
Awareness of the range of values	2.00	**3.45**	1.60	2.83	3.40	3.00	2.85	0.518	93.33
How much could be developed	1.40	3.18	1.40	1.66	**4.40**	2.50	1.74	**0.004**	95.55
How much could be conserved	2.20	3.54	2.00	1.66	**4.00**	1.66	2.28	0.063	95.55
Thoughts about conflict	1.80	2.72	1.40	2.50	**3.60**	2.16	2.71	0.411	91.11
Values they wouldn't compromise	1.00	2.45	1.44	1.66	1.80	1.33	2.71	0.063	84.44
Values they would compromise	1.00	1.90	1.60	1.66	2.00	1.33	**2.14**	0.405	86.66
Usefulness of the mapping process									
Values they wouldn't compromise	3.40	**5.27**	3.00	3.83	1.80	2.83	2.14	0.029	91.11

i) Seven point Likert scale: 1 = not important, 2 = slightly important, 3 = somewhat important, 4 = moderately important, 5 = considerably important, 6 = very important and 7 = extremely important. *ii)*. Group 1 = nature conservationists, Group 2 = soft naturalists, Group 3 = balanced developers, Group 4 = biocentrics, Group 5 = quiet compromisers, Group 6 = developers and Group 7 = off-roaders. Higher values in each row are shown in bold, lowest values in each row are shown in bold and italic (where P <0.005) and italic (where P >0.005). *iii)* Total percentage of respondents who answered each question. *iv)* Indicates the mean group percentage for the area of the Tarkine that respondents mapped for compromise and no compromise.

	Group[ii]							*P*	%[iii]
	1	2	3	4	5	6	7		
N	5	11	5	6	5	6	7		
Values they would compromise	3.40	**5.00**	3.60	3.33	3.00	2.66	3.00	0.375	91.11
Importance of the Tarkine	4.80	5.54	**6.40**	4.00	4.80	2.83	5.00	0.053	95.55
Understanding economic values	5.00	5.18	**5.80**	4.83	5.20	4.16	5.00	0.854	95.55
Understanding natural values	4.20	5.36	**5.40**	4.16	4.40	3.66	5.14	0.459	95.55
Important areas of no compromise[iv]									
Area no compromise for conservation	**29.80**	27.70	0.00	23.10	1.91	2.53	14.52	0.262	53.33
Possible area of compromise	69.30	67.40	96.99	76.90	**97.41**	78.53	86.02	0.457	57.78
Area no compromise for development	3.83	9.90	3.01	0.00	2.03	**18.94**	2.96	0.293	28.89

i) Seven point Likert scale: 1 = not important, 2 = slightly important, 3 = somewhat important, 4 = moderately important, 5 = considerably important, 6 = very important and 7 = extremely important. *ii)*. Group 1 = nature conservationists, Group 2 = soft naturalists, Group 3 = balanced developers, Group 4 = biocentrics, Group 5 = quiet compromisers, Group 6 = developers and Group 7 = off-roaders. Higher values in each row are shown in bold, lowest values in each row are shown in bold and italic (where P <0.005) and italic (where P >0.005). *iii)* Total percentage of respondents who answered each question. *iv)* Indicates the mean group percentage for the area of the Tarkine that respondents mapped for compromise and no compromise.

Table 4-3 – Total percentages for group choices.

(Total Percentages of mapping choices and personal interests and the percentage of responses of attitude groups).

	Group[i]							%[ii]
	1	2	3	4	5	6	7	
N	5	11	5	6	5	6	7	
Mapping choices and other interests								
Areas no compromise for conservation[iii]	**80.00**	72.72	0.00	33.33	60.00	50.00	57.14	66.67
Member of a club or organisation	**80.00**	18.18	60.00	33.33	0.00	66.67	28.57	37.78
Chose a map that reflected their view	60.00	**100.00**	80.00	33.33	60.00	83.33	85.71	75.56
Employed by a business	20.00	81.82	**100.00**	66.67	60.00	**100.00**	66.67	66.67
Willing to compromise map choice	0.00	18.18	**20.00**	0.00	**20.00**	0.00	14.29	11.11
Areas no compromise for development[iv]	20.00	36.36	20.00	0.00	20.00	**50.00**	42.85	42.22
Map choice								
Did not choose a map	40.00	0.00	20.00	**66.77**	40.00	16.67	14.29	24.44
Map K (development 1%, conservation 100%)	**60.00**	18.18	0.00	33.33	0.00	0.00	14.29	17.78
Map G (development 50%, conservation 100%)	0.00	**18.18**	0.00	0.00	0.00	0.00	0.00	4.44

	Group[i]							%[ii]
	1	2	3	4	5	6	7	
N	5	11	5	6	5	6	7	
Map J (development 5%, conservation 100%)	0.00	**9.09**	0.00	0.00	0.00	0.00	0.00	2.22
Map E (development 100%, conservation 50%)	0.00	0.00	**20.00**	0.00	**20.00**	0.00	14.29	6.67
Map D (development 100%, conservation 30%)	0.00	0.00	**20.00**	0.00	0.00	0.00	0.00	2.22
Map H (development 30%, conservation 100%)	0.00	18.18	0.00	0.00	**20.00**	16.67	0.00	8.89
Map A (development 100%, conservation 1%)	0.00	0.00	20.00	0.00	20.00	**50.00**	0.00	11.11
Map B (development 100%, conservation 5%)	0.00	0.00	0.00	0.00	0.00	**16.67**	0.00	2.22
Map I (development 10%, conservation 100%)	0.00	27.27	0.00	0.00	0.00	0.00	**28.57**	11.11
Map F (development 100%, conservation 100%)	0.00	9.09	20.00	0.00	0.00	0.00	**28.57**	8.89

i) Group 1 = nature conservationists, Group 2 = soft naturalists, Group 3 = balanced developers, Group 4 = biocentrics, Group 5 = quiet compromisers, Group 6 = developers and Group 7 = off-roaders. Higher values in each row are shown in bold. *ii)* Total Percentage of respondents who made map choices and reported other interests. iii) Percentage of group respondents that mapped areas that they would not compromise for conservation. iv) Percentage of group respondents that mapped areas that they would not compromise for development.

4.4.3 Spatial conflict

A total of 37 (75%) participants selected a map, 36 (80%) mapped their favourite places, 24 (49%) mapped areas for no compromise for conservation, 12 (24%) mapped areas for no compromise for development, 21 (46%) selected a map and drew areas for no compromise, 5 (11%) did not select a map but drew areas for no compromise and 6 (13%) did not select a map or draw areas for no compromise. Overall, there was unanimous agreement by those who produced or selected maps that 39% of the area was appropriate for conservation and 2% for development. Fifty-nine percent of the area was contested.

Soft naturalists had the highest agreement (99.07%) for conservation generally (Table 4-4). Developers had the highest agreement for development (83.34%) in contested areas. This resulted in soft naturalists and developers having the maximum level of group conflict over contested areas with a higher conservation score. Nature conservationists, soft naturalists and biocentrics also conflicted (to a lesser extent) with developers over the development of these areas. In contested areas that had higher agreement for development, there was a consistent and significant level of conflict between nature conservationists and all of developers, balanced developers and off-roaders.

The data from drawn maps indicated that nature conservationists (37%) and soft naturalists (28%) had the highest levels of agreement between themselves for contested areas to be conserved in contrast to quiet compromisers (0.2%) and balanced developers (0%) who had the least (Table 4-4). Developers had the highest agreement for contested areas to be developed (16%). Consistent with the non-spatial data, nature conservationists conflicted with balanced developers over conservation and developers conflicted with biocentrics over development. Soft naturalists were least likely to compromise, which was inconsistent with the non-spatial data.

Polygons that were classified as having potential for compromise were interrogated for extent of agreement within each group for actions of conservation, development, compromise and favourite places (Table 4-4, Figure 4.4b). Twenty-two percent of nature conservationists had agreement to conserve compromise polygons. For the same compromise polygons, 18% of soft naturalists agreed to conserve and 17% of developers agreed to develop. Whilst these polygons were open to potential compromise the similar levels of entrenched positioning over conservation or development desires by these groups make compromise for opposing land uses potentially difficult.

Favourite places were assessed for willingness to develop or compromise according to agreement within each group (Table 4-4, Figure 4.4). In contested polygons with higher agreement for development across all groups (selected maps), 27% of the balanced developers were willing to develop areas that contained their favourite places. This was the highest level of group agreement to develop favourite places. In polygons nominated for compromise across all groups (drawn maps), 23% of the balanced developers agreed to compromise favourite places. This was the highest level of group agreement to compromise favourite places. This may indicate either weak attachment to favourite places i.e. happy to compromise or develop, as evidenced by their lack of commitment for drawn maps (1 out of 5 drew maps) or they did not consider development as a threat to their favourite places.

The developers had the lowest agreement on favourite places (4%), and were willing to develop more of their favourite areas (9%), supporting the notion that they were most interested in development. Their high desire for development placed them in conflict with nature conservationists, soft naturalists, quiet compromisers and off-roaders, consistent with the non-spatial data.

The selected maps indicated highest levels of conflict dealing with mineral values inland from Temma, around Savage River, Waratah, Rosebery, Tullah and to a lesser extent the pipeline corridor (Figure 4.3a). The drawn maps indicated the highest levels of conflict about wood, minerals and tourism values, concentrating in the northern Tarkine at the South Arthur Forests, Balfour, Arthur River and at Corinna, Savage River and Waratah in the south (Figure 4.3b). When conflict areas for selected and drawn maps were combined, the conflict intensity increased particularly for areas of mineral value inland from Temma, around the Pieman catchment (Rosebery / Tullah) and the Pipeline Corridor. There was a slight increase in conflict intensity for wood resources throughout the Tarkine as a result of the developers' preference to develop most of the timber resource.

Contested areas for selected maps (Figure 4.3a) and drawn maps (Figure 4.3b) were combined to assess overall agreement amongst all groups for actions of conservation or development. There was an average level of agreement ($\bar{x}$=44%) amongst all groups to conserve contested areas, compared to ($\bar{x}$=10%) to develop contested areas. The same combined contested areas for selected and drawn maps were assessed for overall group agreement for actions of conservation or development according to the mapped conservation

(Aboriginal heritage, biodiversity, callidendrous rainforest on basalt, rainforest river landscapes, largest contiguous rainforest, Meredith assemblage, wilderness, aesthetics and old growth forest) and economic (minerals, wood, Pieman impoundment, tourism, carbon) values presented in the workshops. Aboriginal heritage had the highest level for agreement for conservation in areas of conflict across all groups ($\bar{x}$=71%), followed by the Meredith assemblage ($\bar{x}$=61%) and biodiversity values ($\bar{x}$=57%). This was more because conflict areas had minor coincidence with these values than values such as wood and mineral resources. Agreement for development in areas of conflict was highest across all groups for minerals ($\bar{x}$=23%), Pieman impoundment ($\bar{x}$=21%), tourism ($\bar{x}$=14%), old growth forest ($\bar{x}$=13%), and callidendrous rainforest ($\bar{x}$=13%).

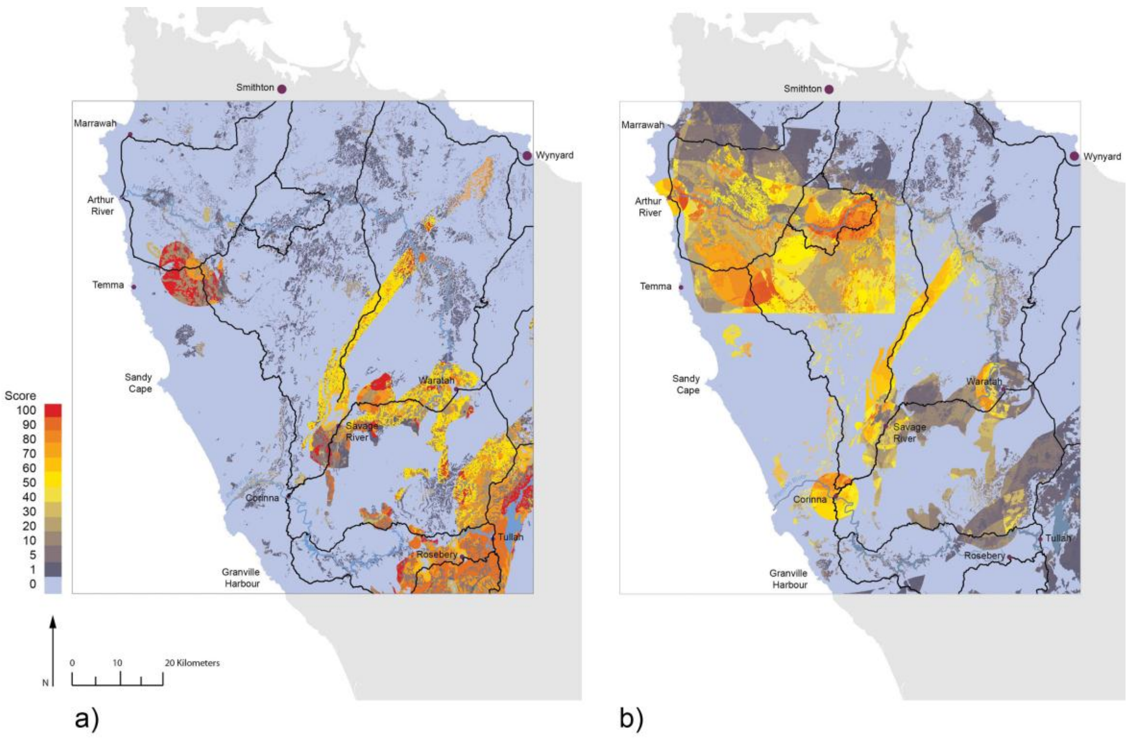

Figure 4.3 – Conflict intensity of contested areas.

(Conflict intensity of contested areas of a) selected maps for development or conservation by attitude groups and b) drawn maps no compromise for development or conservation by attitude groups).

Table 4-4 – Mean score for group agreement.

(Mean score (percentage of agreement) for mapping of conservation and development by attitude groups).

	Group[i]						
	1	2	3	4	5	6	7
N	5	11	5	6	5	6	7
Selected maps							
Contested (higher conservation) conserve	60.00	**99.07**	30.26	33.33	***16.75***	0.00	78.26
Contested (higher conservation) develop	***0.00***	***0.00***	8.45	***0.00***	3.24	**32.41**	***0.00***
Contested (higher conservation) favourite	2.91	6.09	**24.84**	18.07	6.39	***1.56***	17.20
Contested (higher development) develop	***0.00***	52.93	80.00	***0.00***	60.00	**83.34**	40.17
Contested (higher development) conserve	**60.00**	16.19	***0.00***	33.33	***0.00***	***0.00***	***0.00***
Contested (higher development) favourite	4.37	6.35	**27.79**	13.22	9.03	***1.73***	18.30
Contested favourite places	2.80	6.00	**21.12**	14.69	5.69	***1.80***	15.64
Drawn maps							
Contested areas (conservation)	**37.45**	28.89	***0.00***	14.17	0.27	2.21	18.99
Contested areas (development)	0.50	0.26	6.20	***0.00***	2.41	**16.38**	0.07

	Group[i]						
	1	2	3	4	5	6	7
N	5	11	5	6	5	6	7
Contested areas (favourite)	***7.65***	20.61	22.10	14.69	8.55	9.11	**29.00**
Contested areas (compromise)	***0.00***	***0.00***	13.79	10.50	**51.94**	0.42	5.73
Favourite places	5.11	11.93	23.74	13.99	8.93	***4.43***	**23.95**
Potential compromise (conserve)	**22.90**	18.76	***0.00***	4.60	0.17	0.27	8.5
Potential compromise (develop)	1.07	0.80	2.53	***0.00***	1.37	**17.29**	0.64
Potential compromise (compromise)	21.56	***2.25***	17.46	25.11	**55.34**	5.14	36.40
Potential compromise (favourite)	5.13	7.43	**23.05**	13.50	7.70	***3.16***	20.01

i) Group 1 = nature conservationists, Group 2 = soft naturalists, Group 3 = balanced developers, Group 4 = biocentrics, Group 5 = quiet compromisers, Group 6 = developers and Group 7 = off-roaders. Higher values in each row are shown in bold, lowest values in each row are shown in bold and italic.

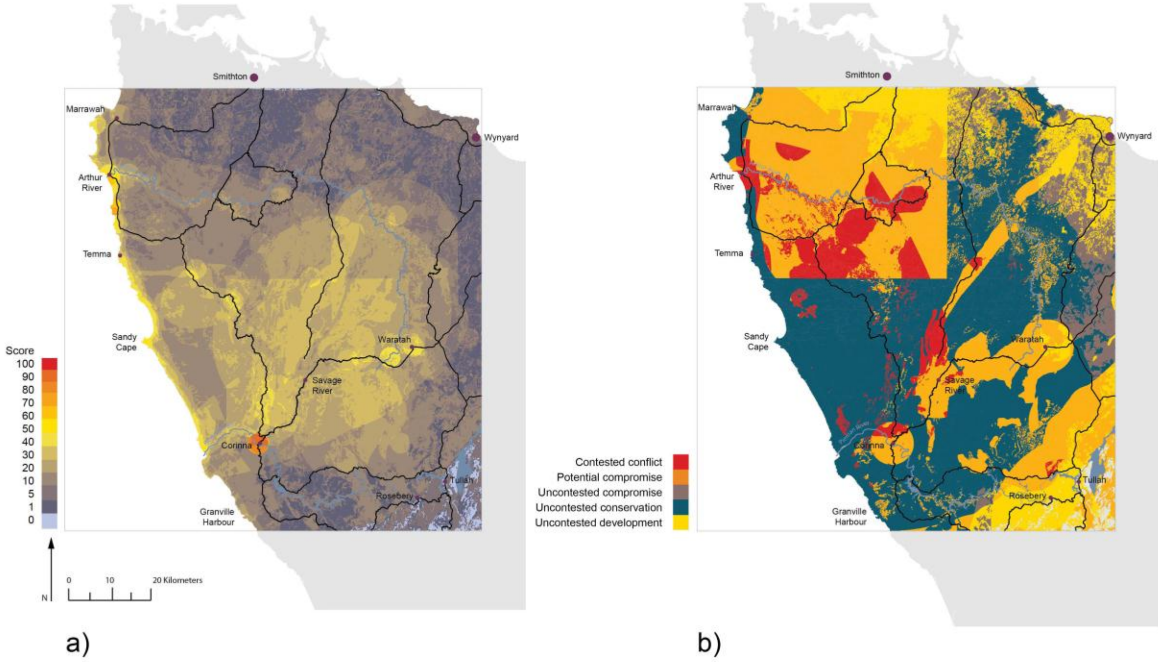

Figure 4.4 – Mapped favourite places.

a) Percentage of agreement for all attitude groups and b) conflict and agreement status.

4.4.4 Attitudinal conflict

Three attitude groups (balanced developers, off-roaders and biocentrics) were most distinct from other groups when the attitudinal factor scores were compared on the two axes (Figure 4.5). The balanced developers were the most divergent and anthropocentric group, valuing hunting in combination with nature, development, ORV, fishing and Aboriginal factors. This placed them in conflict with all other groups as they represented all of the outlier extreme hunters. Their position on the anthropocentric end of continua for recreation activities (ORV, hunting, fishing), socialisation (nature and Aboriginal) and economic interests (development) placed them in polarised conflict with the biocentrics and variable conflict with other groups. The hunting factor represented the most significant conflict due to its dichotomising nature and concentrated group representation.

The off-roaders represented a mix of anthropocentric and biocentric values. They had distinct high anthropocentric valuing of ORV in combination with either high or low scoring for other values. Off-roaders highly valued ORV combined with fishing and socialised recreation with family and friends. They had biocentric preferences for development (higher importance for recreation and low importance for economic development) and disliked hunting whilst highly valuing ORV. This placed them in conflict with all other groups due to their specific preferences for combining ORV with fishing and socialising that other groups did not share. The ORV factor represented the second most significant conflict due to the narrow group interest and high outlier representation.

The biocentrics were the most biocentric group, least valuing development and socialising. They had a specific combination of most biocentric values knowing that the Tarkine is there for nature and wilderness whilst remotely appreciating the landscape. This placed them in conflict with all other groups on values relating to development and socialising. The biocentrics demonstrated a higher biocentric score for the development factor than the social factor, making the development factor the more prominent value in contestation.

The other attitude groups (nature conservationists, soft naturalists, quiet compromisers and developers) were dispersed in their placement on the two conflict factor axes, therefore not represented in concentrated group conflict.

Conflicts were identified by attitudinal differences towards an event occurring in the landscape. The development, social, ORV, activist and hunting attitudinal factors represented significant differences in attitudes toward enacted recreation and landscape modification. The nature, fishing and Aboriginal attitudinal factors represented a gradation of preferences for activities and personal identification that existed mutually in the landscape and did not cause conflict between individuals as singular value preferences. However, when some of these factors were combined with the development, social, ORV, activist and hunting attitudinal factors they strengthened and complicated the conflict.

Three main conflicts were identified: i) development against nature conservation, ii) established recreation against Aboriginal cultural heritage conservation and iii) hunting against wildlife protection. The development conflict involved mutually exclusive preferences for nature conservation or development of natural resources enhanced by conservation activism, enacted by conflict over mining and road construction. The established recreation conflict involved incompatible preferences for ORV, fishing, hunting and partying versus Aboriginal artefact preservation, enacted by ORV on Aboriginal middens. The hunting conflict involved preferences for hunting and partying versus those who did not, enacted by recreational or Indigenous hunting on state land.

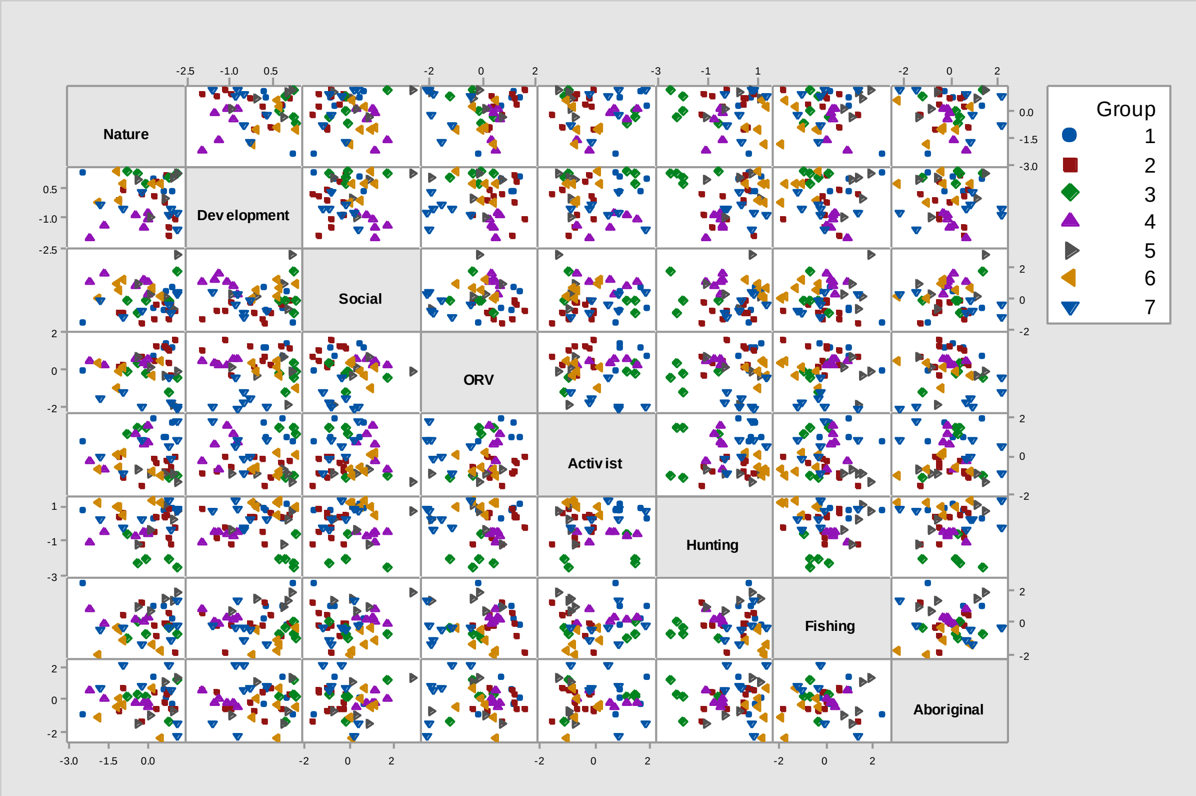

Figure 4.5 – Matrix plot of attitudinal factors by attitude group.

(Group 1 = nature conservationists, Group 2 = soft naturalists, Group 3 = balanced developers, Group 4 = biocentrics, Group 5 = quiet compromisers, Group 6 = developers and Group 7 = off-roaders).

4.4.5 Willingness to compromise

Twenty-one individuals selected a map and drew areas that they would not compromise. Seven were female and 14 were male. Participants represented all of the attitude groups except for the balanced developer group. The 7-point Likert scale questionnaire scores that individuals gave for how much the PGIS process had changed their thinking and how useful the mapping process was for deciding what values they would or would not compromise had no relationship to their compromise score.

The most explanatory model (r^2 = 84%) for compromise score involved an interaction effect between gender and importance of conservation management. Females who indicated that conservation management was the most important issue relating to the Tarkine were inclined to have a low tendency for compromise (Figure 4.6) compared to the other three classes (1. males who rated conservation management as most important, 2. males who rated conservation management as not important and 3. females that rated conservation management as not important).

Similarly, females who indicated that conservation management was the most important issue relating to the Tarkine were also less likely to compromise conservation values (Table 4-5). This model explained 84% of the variation.

Of the females who had the lowest compromise score ($\bar{x}$=37%), three were in the soft naturalist attitude group and one in the off-roaders group. The two lowest compromise scores were from women who identified as Tasmanian Aborigines. They were the only Tasmanian Aboriginal people who completed both mapping exercises. Three of the low compromise scoring females were tertiary educated and were not employed by a business that had any interest in the Tarkine.

The other females who rated conservation management as not important had a similarly high compromise score ($\bar{x}$=89%) to that of males ($\bar{x}$=88%) who rated conservation management as not important. Two of these women were categorised as soft naturalists and one as a nature conservationist. All three were tertiary educated and two were employed by a business that had interests in the Tarkine.

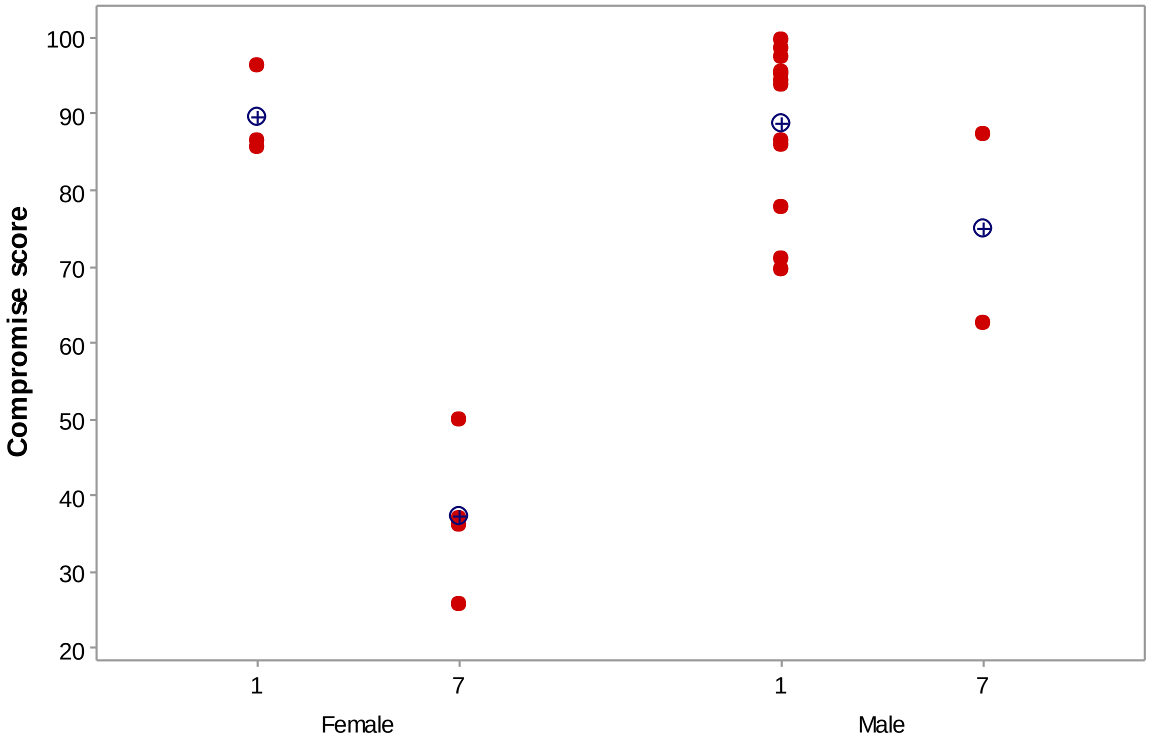

Figure 4.6 – Compromise model.

(Compromise score, gender and importance of conservation management relating to the Tarkine. (1=conservation management not important, 7=conservation management most important, ●=individual compromise score and ⊕=mean compromise score).

Table 4-5 – General linear model.

Using adjusted SS for tests for compromise of conservation values, gender and importance of conservation management.

Factor						
Gender = female, male						
Conservation importance = 1, 7						
Source	**DF**	**Seq SS**	**Adj SS**	**Adj MS**	**F**	**P**
Gender	1	1508.9	473.1	473.1	7.36	0.015
Conservation importance	1	2790.3	2790.3	2790.3	43.42	0.000
Gender*conservation importance	1	1507.9	1507.9	1507.9	23.46	0.000
Error	17	1092.6	1092.6	64.3		
Total	20	6899.5				
S = 8.01684		R-Sq = 84.16%	R-sq(adj) = 81.37%			

4.5 Discussion

4.5.1 Environmental conflict is multidimensional

The results in the present study are consistent with the generalisations that environmental conflicts are multidimensional, involve diverse value orientations and are influenced by many factors (Zarsky 2002; Purvis & Grainger 2013). Environmental conflicts over land are common and widespread around the world and are exacerbated by competing value orientations (Gritten et al 2012; Redpath et al. 2013). Value orientations toward development and conservation are described within ecocentric, biocentric and anthropocentric continua according to the conflict being investigated (Dunlap et al. 2000; Gangaas, Kaltenborn & Andreassen 2014; Keltenborn, Andersen & Nellemann 2009; Keltenborn, Nyahongo & Kideghesho 2011; Keltenborn & Bjerke 2001).

The results in this thesis support the notion that participants held multidimensional views about conservation, development and recreation. Participants did not have mutually exclusive biocentric or anthropocentric positions, instead they had both anthropocentric and biocentric preferences across all values. The multi-dimensionality of conflict between individuals and attitude groups became evident when preferences for values were considered simultaneously. Three strong environmental conflicts in the Tarkine were indicated by differences in attitudes, the spatial distribution of preferences for land use, arguments in the courts and mass media and the potential for negative interactions on the ground. Conflict centred on the classic ‘growthists’ versus ‘greenies’ conflict between logging/mining and protection for nature conservation was strongly evident in the first two axes of the ordination and in the contrast in attitudes and mapped preferences between attitude groups. Independently, there was strong evidence of conflict between ORV enthusiasts and both those who value quieter forms of recreation, and those who abhor the damage these vehicles have inflicted on natural and Aboriginal values in the Tarkine. This conflict over ORV access was strongly apparent in the analyses of attitudes, and has been the focus of much public debate over the future of the Tarkine. The third conflict that might manifest in land use was between those who recreate by killing native wildlife and those who disapprove of these activities on animal welfare or conservation grounds, with the disapproval being stronger for hunting than fishing. This particular conflict has not been reported in the media in relation to the Tarkine, but is clearly present in the attitude analyses in this thesis.

There is a polarised debate between ‘growthists’ (pro-developers) and ‘greenies’ (conservationists) over mining and forestry land use in the Tarkine, as elsewhere in Tasmania (Kirkpatrick 1987, 1988), but resolution of this debate, as was achieved by the protagonists in the forest accord process in Tasmania (Macintosh & Denniss 2012; Tasmanian Government 2011a), does not necessarily satisfy the land use desires of those who are focused on other conflicts, as witness the political rejection of the agreement from this same forest accord. The reservation of unprofitable forest or mineral deposits does not please hunters and ORV drivers, who see this result as further restriction on their recreation, while not necessarily being devotees of development.

In order for a conflict to exist there must be an enacted event involving polarised opinions (Kirkpatrick 1987). The off-road vehicle driving conflict was enacted, involved public protests (Ford 2012-2014), legal action (Ryan & Bryan 2014; The Advocate 2015) and personal conflict, and therefore represented a substantial conflict. The development conflict was enacted through mining leases, mining operations and road construction protests (Croxford 2013; Santhebennur 2013; Tranter 2009, and legal action (Cullen 2015) and involved personal conflict (Ford 2013; Sims, Wilson, Johnson 2015, pers. comm., 18, March). Conflict may also involve a strong disagreement or collision of values, needs, interests or intensions among individuals, groups, organisations, or communities creating negative dislike of person or organisation (Hovatter 1997).

The hunting conflict represented a polarisation of opinion rather than an experienced conflict. However, the strength of the polarisation regarding hunting and its associations with other anthropological values made it an important conflict to consider. Hunting conflicts are polarised and focus on moral arguments relating to biological sustainability, animal welfare, nature conservation, human subsistence and recreation (Leader-Williams 2009). Attitudes to hunting have been categorised within continua of the legitimacy (acceptability of hunting) to illegitimacy (unacceptability of hunting) (Fischer et al. 2013). The hunting continuum in the present study was dichotomised between those who were negative or neutral about hunting and those that valued hunting in combination with preferences for connecting with European heritage and socialising. Participants in the present study reported that they were hunting for recreational or cultural purposes. Recreational hunting of wallaby (*Macropus rufogrisues*) in Tasmania is legitimised by arguments relating to crop and forest plantation protection (Boom & Ben-Ami 2010), pest control (Boom et al. 2012) and provision of dog meat (Guiler 1972). Wallaby meat was seen by many as inferior meat (Hercock & Tonts 2004), but is now sold in butchers shops for human consumption. The recreational hunters in the present study were hunting wallaby and rabbit not for personal consumption, but as an activity that allowed them to be in nature. The continuum in this thesis was consistent with the moral arguments and polarised conflicts of the European recreation hunters, who legitimise their hunting as a learning experience in nature, and an opportunity to develop skills and enjoy the thrill of the hunt whilst socialising (Fischer et al. 2013). Although European recreational hunters are not a homogenous group (Heberlein, Serup & Ericsson 2008), the participants in the present research had consistent demographic attributes with the European recreational hunters such as higher male representation, rural residence and proximity to forested land (Heberlein, Ericsson & Wollscheid 2002; Heberlein, Serup & Ericsson 2008).

The legitimacy of hunting is influenced by the cultural context and personal motivation of the hunt (Leader-Williams 2009; McCorquodale 1997) and by human consumption of the meat (Fischer et al. 2013; Kellert 1984). Hunting for genuine cultural reasons such as exercising cultural practice in specific places is viewed by non-hunters and hunting critics as legitimate (Fischer et al. 2013). Indigenous hunting practices are legitimised by subsistence and ceremonial purposes (Kellert 1984) and perceived as ‘need-driven’ compared to recreational hunting as ‘opportunity-driven’ (McCorquodale 1997). Indigenous hunting conflict focuses on differences in cultural views of hunting by recreational hunters (McCorquodale 1997). The lack of legal recognition of Aboriginal rights to hunt and practice culture (Bauer & Giles 2002; Bowman & Robinson 2002) and the imposition of recreational hunting regulatory systems on subsistence and ceremonial hunting has been interpreted as a ‘cultural assault’ on indigenous cultures (McCorquodale 1997). In the present study, two Aboriginal participants reported that they hunted mutton bird (*Puffinus tenuirostris*) and crayfish (*Jasus edwardsii*) for cultural reasons, were opposed to sport shooting but supported hunting for feral animal pest control. These two participants viewed hunting (including fishing) as an important cultural practice, an exercise of cultural rights, and a social justice issue and therefore irrelevant to Eurocentric value systems. The hunting continuum in the present study thus is perhaps more complex, multi-faceted and conflictual than reflected in the results and may involve a majority against recreational hunting.

The present study showed that conflict relating to recreation focussed on mechanised versus non-mechanised activity. Previous studies have commonly used the recreation opportunity spectrum (ROS), a continuum of recreation experience based on access and density factors (Clark & Stanky 1979; Pettengill & Manning 2011) or the recreation specialisation construct, a continuum of progression of involvement (Bryan 1977; Oh, Sorice & Ditton 2011). These continua are used for recreation management. They are therefore irrelevant for expressing attitudes beliefs and behaviour behind recreation preferences (Kil, Holland & Stein 2012;

McCool, Clark & Stankey 2007; Oh, Sorice & Ditton 2011). The off-road vehicle driving continuum in the present study reflects a unique combination of attitudes toward recreation mode, beliefs about Aboriginal cultural heritage sites, identification as a conservationist and behaviours toward nature.

Conflicts between indigenous people and recreating non-Indigenous people occur because of differences in values attached to Indigenous rights, sacred natural areas and subsistence activities (Zeppel 2010). The off-road vehicle driving continuum in the present study involves oppositional differences in preferences for ORV activity and connecting to European heritage versus protection of Aboriginal cultural heritage and nature conservation. Whilst there is evidence that people have preferences for connecting with European heritage values (Cubit 2001; Lennon 2000) or Indigenous heritage values (Notzke 2004) whilst recreating, such preferences are usually considered as independent phenomena, not as an integrated continuum. Maintenance of European heritage (i.e. shacks, stockman's huts and cattle yards) can conflict with desires for naturalness, whereas Indigenous peoples' use of cultural heritage areas can conflict with archaeological conservation (Lockwood, Spennemann & Johnstone 2000). The recreation conflict in the present study involves a specific clash of values about the degradation of nature and Aboriginal cultural heritage caused by mechanised recreation.

The results in this thesis were consistent with the generalisation that non-mechanical recreation is associated with preferences for fishing, canoeing and hiking and a deeper connection while mechanical recreation is associated with a preference to socialise with like-minded people (Budruk, Virden & Waskey 2009; Kil, Holland & Stein 2012). Conflict between non-mechanised and mechanised recreationalists is caused by social and psychological differences in behaviour and views of how public lands should be treated (Owens 1985; Rogers 2011). Studies show that the conflict is asymmetrical, that is the non-mechanised recreationists feel that their experience is degraded by the presence of mechanised recreationists, but the mechanised recreationists are not affected by conflict encounters (Adams 2009; Noe, Wellman & Buhyoff 1981; Rogers 2011). Non-mechanised recreationists hold negative views about the destructive impacts of mechanised recreation such as soil erosion, users creating new trails, going off trials and going too fast (Chavez & Knap 2006; Pierskalla, Schuett & Thompson 2011). In the present study, participants who had no interest in recreation or were non-mechanised recreationists viewed mechanised recreation as a significant threat to the Aboriginal cultural heritage and high natural values of coastal areas. Although mechanised recreationists are not a homogenous group (Burr et al.

2008), the participants in the present study had consistent demographic attributes such as higher male representation, and lower education attainment compared to non-mechanised recreationalists (Adams 2009; Burr et al. 2008; Kil, Holland & Stein 2012) but were older (80% over 60 years old).

The results in this thesis indicate that conflict relating to development focussed on fundamental differences in the valuing of nature and was epitomised by the dichotomised ideologies of the biocentrics and the balanced developers. Deep ecology can be characterised as an attitude toward the biosphere that is non-anthropocentric, ecocentric and aspires for equality between humans and nature through ecological consciousness (Leopold 1949; Naess 1973; Hurwich 1986; Walker 1994; Sessions 2014). Deep ecologists have no specific trade-off principles between natural and human values (Hurwich 1986; Bryan 1991), rather they have a biocentric value orientation and view ecosystems independently from human use (Vaske & Donnelly 1999). The biocentrics in the present study had ideals that were consistent with the principles of deep ecology and were concerned about ecological issues: biodiversity conservation, habitat protection, wilderness preservation, conservation tenure management and bio-security. The only anthropological interest they reported was Aboriginal cultural heritage protection and Aboriginal land justice issues. In regard to development, some biocentrics had desires for existing roads in the Tarkine to be closed, no new roads to be constructed and to confine future development to sustainable tourism and education.

‘Wise users’ and ‘new conservationist’ are used to describe attitudes toward the natural environment predicating that preservation and development can be integrated (Clarke 2002; McCarthy 2002). Wise users / new conservationists view human rights as valid as those of the environment and believe that the equitable distribution of natural resources can contribute to human quality of life (Wilson 1997; Clarke 2002). Wise users defend cultural identity, local knowledge and community traditions against threats by states and urban environmentalist to lock-up landscapes or impose environmental regulations (Wilson 1997; McCarthy 2002). The balanced developers in the present study valued the Tarkine for the lifestyle and community spirit it provided and desired sustainable development and multiple-use of the natural resources, representative of the sentiments of wise users / new conservationists.

Demographic and social group factors influence attitudes toward environmental conflict (Balram & Dragićević 2005; Guthiga 2008; Eilam & Trop 2012; Suryawanshi et al. 2014;

Ryan 2005). The results in this thesis indicated that conflict was influenced by suppressed attitudes toward Tasmanian Aboriginal cultural values. Indigenous and non-Indigenous people hold different values about identity and connection to land (Behrendt & Kelly 2008). Indigenous people value the protection of Indigenous cultural heritage considerably more than non-Indigenous people, and non-Indigenous people are more concerned about environmental issues than Indigenous heritage (Rolfe & Windle 2003). The results in this thesis showed that those who were more concerned with the protection of Aboriginal cultural heritage than connecting with European heritage represented all positions on the nature conservation and recreation continua and identified as Aboriginal and non-Aboriginal. Those who highly valued Aboriginal cultural heritage placed equal value on its importance of habitat for plants and animals to the Tasmanian community. This unusually strong concern for the protection of Aboriginal cultural heritage relative to environmental issues by non-Aboriginal people may be due to several factors. Studies have shown that anti-racism is correlated with high guilt and empathy toward people of other ethnicity (Pedersen et al. 2004; Spanierman, Todd & Anderson 2009; Spanierman, Beard & Todd 2012; Kordesh, Spanierman & Neville 2013). Tasmanian has a shameful history of mistreatment of Aboriginal people (McFarlane 2008; Clements 2014) potentially causing collective guilt and empathy amongst some non-Aboriginal people. Some participants may hold such emotions. Another possibility is that the conspicuous Aboriginal shell middens that are often the focus of heritage protection conflict are perceived as aesthetically pleasing, part of the natural landscape and a symbol of guilt and loss for the treatment of Aboriginal people. In this regard, the valuing and treatment of Aboriginal middens may represent a fault line of conflict influenced by history and fear of ongoing cultural loss through destructive recreational activity.

People's perceptions towards other ethnicities are influenced by history, identity, discrimination, social relationships and the individual choices they make to meet their own ends (Lake & Rothchild 1998; Lutz 2005). In Australia racial prejudice toward Aboriginal people is linked to male gender, lower levels of formal education, right-wing political orientation and older age groups (Pedersen et al. 1997, 2000, 2004; Pedersen & Walker 1997). The results in this thesis indicate that those who privilege connecting with European heritage over Aboriginal cultural heritage were male, over 45 years of age and had secondary and technical college level education. They were among the most anthropocentric and devoted to traditional recreation. Although the difference in the Likert scores for participants who valued European heritage more than Aboriginal cultural heritage was minimal it did not indicate the strength of racial prejudice. Participants who were interviewed individually expressed negative views about middens and Aboriginal culture, consistent with the results gained in the same geographic area by Good (1991), whereas those that participated in groups did not. Those that made prejudicial comments slightly valued European over Aboriginal heritage, equally valued Aboriginal and European heritage or marginally valued Aboriginal heritage over European heritage. The PGIS process may have suppressed the expression of racial prejudice.

4.5.2 Triangulation of non-spatial and spatial data

Self-reporting methods are limited by the ability, willingness and value lenses of research participants (Hobson 2006). However, triangulation of multiple sources of self-reporting can illuminate underlying biases and complexities (Cohen, Manion & Morison 2007; Rothbauer 2008) and is used in PGIS (McCall & Minang 2005; Elwood 2009).

Attitudes toward green urban spaces (Balram & Dragićević 2005; Tyrväinen, Mäkinen & Schipperijn 2007), conflict resolution and land use planning (Zhang & Fung 2013), social values of ecosystem services (Sherrouse, Clement & Semmens 2011) and mapping creativity (Brennan-Horley & Gibson 2009) have been determined using methods that integrate non-spatial and spatial data. Integration of non-spatial and spatial data can improve the confidence of results, reveal the multi-dimensional nature of attitudes, provide insight into values that influence perception, illustrate connections between social values, attitudes and the environment, and reveal personal and social preferences, (Balram & Dragićević 2005; Tyrväinen, Mäkinen & Schipperijn 2007; Brennan-Horley & Gibson 2009; Sherrouse, Clement & Semmens 2011; Zhang & Fung 2013).

Whilst integrating spatial and non-spatial data is useful, reciprocal triangulation methods can improve results by solving weaknesses of interpretive analysis of qualitative data and statistical analysis of quantitative data (Erzberger & Prein 1997; Amoeretti & Preyer 2011). Non-spatial data have been triangulated with spatial data to map ecosystem services (Ramirez-Gomez et al. 2015), flood risk management and vulnerability (Chingombe et al. 215; Nethengwe 2007) and drought impact (Lovell 2011). These studies triangulated survey, interview, workshop and PGIS map data to solve environmental problems by improving the accuracy and availability of data and unearthing local knowledge. Triangulation methods were non-reciprocal and did not use attitude syndromes. Studies that use reciprocal triangulation between attitude syndromes and PGIS spatial preferences appear to be absent in current research.

The reciprocal triangulation between the objective spatial (selected maps), the subjective spatial (drawn maps), survey, interview and workshop data illustrated the geographic extent and types of values in conflict and the temporal change in land use choices during the PGIS workshop. When the four data sources were triangulated, there was a shift in land use preferences between the non-spatial and spatial and the potential scope for spatial conflict and compromise was established. The level of group agreement for land use actions and the intensity and types of spatial conflict by attitude groups could be measured when non-spatial and spatial data were triangulated. The relationships between demographics, attitudes and preferences for spatial compromise could also be determined by triangulation of data.

The results were biased toward the objective spatial data, as the participation rate was higher (71% across all attitude groups) than the subjective spatial mapping exercise (50% for mapped areas of no compromise for conservation and 27% for development). This deficiency may relate to the reluctance of individuals to commit lines to paper due to the political nature of the research, a lack of knowledge or confidence, or participation fatigue (Pfeffer, Martinez & Sridharan 2011). Regardless, the subjective spatial data provided interesting insight into preferences for locales for development. For example, although the economic valuing of the wood resources was accepted, some wanted the development of unviable resources to continue. There was a tendency for minimal compromise for development of places where people worked, or conservation of places where people recreated. Strangely, some were happy to develop their favourite places. Perhaps this outcome says something about their interpretation of the word ‘develop’ or ‘conserve’. It seems likely that ‘favourite’ is a label that can be applied to development if a person is in favour of development.

The ability of participants to respond to the data collection methods may have influenced the results. Spatial skills such as map reading may vary between males and females, with females demonstrating lower abilities, which can be improved with minimal training (McAuliffe 2003; Uttal et al. 2013). The soft naturalists group had the highest percentage of female participants (64%) and the largest change between the non-spatial and spatial scoring compared to the developers who had the highest percentage of male participants (83%) who changed their position least. This may be due to an increased awareness of the values by the soft naturalists as a result of exposure to the objective maps and or an improvement in spatial skills during the workshop. Individuals can suppress their thoughts during group conversations dependent upon combinations of personal orientations (Webster 2006). This was supported by the prejudicial comments in the present study being shared in personal interviews only. The triangulation and integration of multiple data sources can therefore provide new insights beyond dichotomous views and expose latent interaction between phenomena (Jabbour, Santos & Nagano 2010). Given the variable results, one could conclude that the triangulation and integration of multiple data sources has exposed either underlying fixed positions or latent conservation tendencies.

4.5.3 Attitude groups and their relevance

There was consistency between group preferences and demographics with attitude groups elsewhere. The ‘third cohort’ of Hay (2008) and the ‘traditional land users’ of Cubit (2001) have the attachment to place and traditional economic and recreational use of natural areas consistent with the attitudes and preferences of the balanced developers group in this study. The gender, geographical proximity to forested land and rural residence of the balanced developers was consistent with attributes of the European recreational hunters (Heberlein, Ericsson & Wollscheid 2002; Heberlein, Serup & Ericsson 2008). The gender and education profile of the off-roaders group was consistent with demographic attributes of mechanised recreationalists (Burr et al. 2008; Adams 2009; Kil, Holland & Stein 2012). McFarlane and Boxall (2000) found concentrated biocentric attitudes toward forests in urban populations. The biocentrics group in the present study were exclusively urban.

4.5.4 Informed discussion and willingness to compromise

The results in the present study supported the hypothesis that informed discussion of values leads to increased willingness to compromise. This result was unexpected, particularly the extent of compromise given the lack of definitive evidence that group discussions leads to a consistent moderation of views (Black et al. 2011; Wojcieszak 2011). Views about development and conservation of land are considered to be strongly held (Fischer & Young 2007; Stewart et al. 2011; Sayer et al. 2014). Given that participants were sourced from conflicting parties, it would be reasonable to expect that their values would be established and further reinforced by the like-mindedness of group participants (Mercier & Landemore 2012) and therefore unlikely to change (Petty & Caccioppo 1990; Wojcieszak 2011). However, the extent of compromise exhibited in the difference between the two spatial exercises was substantial.

The willingness to compromise amongst participants may have been due to the structure of the PGIS workshops. The workshops may have created a positive environment for attitude change by providing sufficient time for participants to methodically work on their own and deliberate together in response to large amounts of new information (Pieroo et al 2004; Bohner, Erb & Siebler 2010; Moser & Dilling 2011; Davidson 2014). The drawn map was the key measure for compromise, as this was the last task participants had time to reflect on their deliberations in the absence of group influences.

Personal attitude traits impact upon an individual's ability to compromise (Petty & Caccioppo 1990; Wojcieszak 2011; Nisbet et al. 2013). Although the workshop groups comprised of like-minded people, they did not necessarily have the same philosophical view. There was no evidence of intra-group polarisation, or great differences of opinions within groups, which may have facilitated good listening and eventual understanding of the views of others and moderation of attitudes.

Participants that were least willing to compromise might have held deep personal place connections and/or cultural identity that could not be easily influenced by the PGIS process. The correlation between gender (female) and valuing of nature conservation has been well established (Kellert & Berry 1987; Kruse 1999; Czech, Devers & Krausman 2001; Anthony 2002; Kollmuss & Agyeman 2002; Rauwald & Moore 2002; Eisler, Eisler & Yoshida 2003; Hunter, Hatch & Johnson 2004; Uitto et al. 2004; Hinds & Sparks 2011; Baharuddin, Karuppannan & Sivam 2013). The results in this thesis were consistent with this research as over half of female participants were among the least willing to compromise nature conservation values. They reported spiritual connection as a main reason for visiting, concern for Aboriginal heritage protection and a desire to set aside areas for wildlife protection excluding humans. The two individuals that had the lowest compromise scores were Tasmanian Aboriginals who indicated that enough compromises had already been made and were unwilling to support further destruction of conservation and Aboriginal heritage values. These women portrayed an Aboriginal environmental ethic and connection to Country not shared by non-Aboriginal participants, a cultural difference found in other studies (Graham 1999; Sherry & Myers 2002; Rose & Robin 2012; Kingsley, Townsend & Henderson-Wilson 2013). Their reluctance to compromise may have been influenced by the absence of group moderation as these two women participated in individual interviews.

4.6 Summary

It is concluded that the participants in the process were not simply dichotomised between developers and greenies, but, individually had mixed responses on eight independent factors that were labelled nature, development, social, off-road recreation, activism, hunting, fishing and Aboriginal. Conflict centred on higher anthropocentric valuing of traditional recreation values such as hunting and off-road vehicle driving and on biocentric valuing of nature conservation against development of mineral and wood resources. The PGIS process used in this thesis revealed an inclination for most respondents to increase their readiness to compromise as a result of increased understanding of the values of the Tarkine. Participants with deep personal place connections and/or cultural identity were not easily influenced by the PGIS process and were least willing to compromise. Females who valued nature conservation were the least prone to compromise in response to data input.

This present study used a novel combination of data on attitudes and PGIS to identify the nature and distribution of conflict in the Tarkine region. The reciprocal triangulation of all data sources illustrated the geographic extent and types of values in conflict and potential scope for spatial conflict and compromise that would otherwise have been difficult to determine. It allowed relationships between demographics, attitudes and preferences for spatial compromise to be measured and the level of group agreement for land use actions and the intensity and type of spatial conflict according to groups to be determined. This method of reciprocal triangulation of attitudes and PGIS to identify the nature and distribution of conflict may have application in contested regional settings elsewhere in Australia and may be useful in expanding the knowledge for other PGIS processes.

Chapter 5 An integrated approach to conflict compromise

5.1 Introduction

The aim of this thesis was to develop an integrated approach to resolving land use conflict using the Tarkine as a case study. The research process concentrated on determining levels of agreement for optimal land use in the Tarkine by establishing spatial patterns using two approaches: a) the *a priori* approach to determine the different levels of significance and the relative worth of values and b) the *a posteriori* approach to determine the importance of values to people. The first two chapters of the thesis quantify the objective conservation and development values and the last chapter (Chapter four) quantifies the trade-off between the two. Whilst this thesis is place specific, it aims to contribute to scholarly knowledge by demonstrating how potential compromise in any region of land dispute can be reached by firstly understanding the extent and nature of conflict and secondly the scope for land use resolution and / or compromise. This thesis has combined well established PGIS, attitude and value preference, conservation significance and economic valuation techniques in a new way that may be an improvement on current land use valuation methods.

Although this thesis is a rigorous multifaceted valuation, a second phase of participant involvement may be required to explore the potential for agreement based on ongoing negotiations. The second half of this chapter will provide an example of how the research from this thesis may be applied in a second engagement process, to demonstrate its potential application and inherent flexibility.

5.2 A coherent framework for real world practice

There are a plethora of participatory decision making processes and practices that aim to resolve differences between actors and stakeholder groups (Margerum 2008; Robinson et al. 2011; Webler & Tuler 2006). Practices involve participatory planning processes that facilitate practical decision making whereby equal participation opportunity is given to stakeholders (Forester 1999; Margerum 2002). Also known as ‘communicative practice’, ‘discourse’ model planning and ‘deliberative practitioner’, these planning approaches involve hearing people’s value judgements as part of the decision making process (Taylor 2001).

The research processes in this thesis demonstrates a deliberative practice of scoping the potential of conflict compromise by elucidating participants' attitudes and preferences toward land use trade-offs. A coherent framework has been created whereby multiple values are established systematically, their relationships analysed and practical land use options discussed.

Resolving environmental conflict will require an understanding of the complex relationships between the significance of natural values and the human demand for its resources. A coherent and practical approach to quantifying complex environmental conflict in the Tarkine and scope for compromise has been presented in this thesis. The present thesis seeks to quantify the values in contestation and elucidate their multiple valuing through reciprocal interpretations. The results show that the nature and extent of conflict and compromise can be explained spatially and non-spatially. The integrated approach developed in this thesis may be a useful tool for decision makers.

5.3 New integrated approach to measuring values and compromise

This thesis provides a new integrated approach to quantifying complex relationships between diverse values using common technologies within a regional context. It uses ordinary methods for collecting and analysing data but a novel combination of spatial and attitudinal data.

Well-established methods were used to map, collect and analyse data for each of the substantive chapters of the thesis. For mapping and scoring conservation and development values the present thesis used weighted concentration and presence, weighted sum, absence / presence and proximity analysis methods in chapters two and three. Questionnaires, audio recordings and group discussions and mapping tasks were used in the PGIS workshops and interviews to collect attitudinal and preference data in chapter four. Legal recognition of importance, relative distribution, rarity, and distinctiveness were used to determine the level of significance of conservation values in chapter two. Cost-benefit analysis (CBA) and the net present value (NPV) approach were used to determine the level of economic significance of development values in chapter three. Common statistical methods were used for determining attitudinal factors, attitude groups and the willingness to change model such as varimax principal component analysis, cluster analysis, multiple comparison procedure and regression analysis in chapter four.

However, this thesis used a novel combination of these well-established methods to create and analyse the data. Firstly, a vector approach was used in the GIS database to record and analyse the data rather than the more common raster approach. This provided a refined data at small scale (a minimum of 90% accuracy and sampling at 1:25,000), allowing detailed insight to the sensitivity of significance scores and the spatial impact of conservation and development priorities. The vector approach allowed accurate representation of the maps produced by the workshop participants. Secondly, a highly integrated GIS database was created, combining spatial and non-spatial inputs, including attitudinal group preferences. Thirdly, the reciprocal triangulation method that was used between attitude syndromes and PGIS spatial preferences appeared to be absent from current research. The novel approach of using reciprocal triangulation of multiple data sources, multiple methods and the integration of different method approaches in the present thesis gave new insights to the geographical, social and political nature of the extent and type of values being contested, those that were uncontested and the scope for compromise (Figure 5.1).

This novel approach revealed the extent and nature of the natural and economic values, their significance, relativities and distribution and the attitudes and preferences around conflict and willingness to compromise at a refined scale. The result of this work was an integrated valuing of the Tarkine, that demonstrated using *a priori* and *a posteriori* approaches, how participants' preferences and choices translated into spatial and social conflict and their willingness to compromise. This process made conservation and development trade-offs more dynamic and representative of the complex multi-dimensional nature of values in contestation, rather than the uni-dimensional approach used to address most specific environmental problems.

Although others have mapped and quantified alternative future modelling and development scenarios (Steinitz et al. 2005; Nelson et al. 2009; Goldstein et al. 2012) or mapped community preferences and conflict (Brody et al. 2004; Raymond & Curtis 2013), the present thesis provides a new integrated approach to measuring values and scoping conflict compromise. A particular point of difference in the present research was the integration of attitudinal preferences of ordinary people who were experiencing conflict, and their engagement in the PGIS process where they could choose from a range of unbiased and biased trade-off maps and map their own compromise thresholds. This provided rich data allowing further analysis of areas that were uncontested and the scope for compromise.

5.4 Value of the approach

5.4.1 Substantive quantification of values present in the Tarkine

A substantive quantification of conservation, development and attitudinal values present in the Tarkine has been established in this thesis. Some conservation values were globally significant and may meet criteria for World Heritage listing (Aboriginal cultural heritage, coastal interdigitation, rainforest river landscapes, wild Dasyuridae habitats), some were likely to increase in significance over time (Aboriginal cultural heritage, biodiversity and wilderness) and the international significance of the Aboriginal cultural landscape in the Tarkine has not been fully determined. There was high economic potential for carbon and tourism development in the Tarkine, and high potential for localised mining activity. The transport infrastructure cost of tourism and carbon development was minimal compared to mineral and wood development, although improvement in the road network may have social benefits. Spatial conflict between development and conservation values occurred where both mineral and rainforest coincided with existing road access. Those who participated in the present research were not simply dichotomised between developers and greenies, but held multidimensional views that were not mutually exclusive and had both anthropocentric and biocentric elements. The three most apparent conflicts were between a) developers and conservationists over mining and road construction, b) recreationists and those supporting conservation of Aboriginal cultural heritage over ORV driving on middens and c) hunters and those supporting wildlife protection. Females who valued nature conservation were least prone to compromise as were those who held deep personal place connections and or cultural identity.

The analytical framework presented in this thesis provided a transparent and flexible quantification system for identifying values and areas of no conflict, conflict and potential agreement. The three most apparent conflicts (listed above) were identified using reciprocal triangulation of data produced from the *a priori* and *a posteriori* quantification phases of the research. Although it would be reasonable to anticipate that conflict between logging and carbon would be reported as an apparent conflict, it did not emerge for several reasons. The sensitivity analysis of the economic valuation reported that the mineral resource was the most stable development resource using output multiplier and non-multiplier scenarios, with the carbon, wood and tourism less so. It was concluded that under most variables, spatial conflict was concentrating around mineral development. Although logging and carbon conflict was present in the spatial *a priori* analysis, it did not emerge as an issue during participant workshop and interviews. This may be due to the notion that carbon markets may have been perceived by participants as ‘not here yet’, or that the expansion of logging may not have been perceived as a threat. However, the logging and carbon conflict may become more evident in the future should policy regimes change whereby the carbon potential of the region is realised and or political processes allow more logging. Thus, the methodology presented in this thesis has provided a means of elucidating both the contemporary and future values present in the Tarkine and their current and potential conflict.

5.4.2 Elucidation and commensuration of values across inherent and abstract spectra

The results from the present thesis demonstrated that it is possible to elucidate and commensurate natural, human use and social values within a regional context across inherent and abstract spectra. The spatial pattern and best land use in the Tarkine was established by creating a robust commensurate significance valuing between areas of conservation and development. The heritage importance of conservation values in the Tarkine found in the present research was consistent with the findings of others (Harries 1995; The Wilderness Society 1992; Law 2009; Fletcher & Thomas 2010; Hitchcock 2012). The *a priori* significance scoring for conservation values in the present research were robust when tested for sensitivity against the *a posteriori* significance scoring provided by the PGIS participants (Appendix 7.1). The valuing of the mineral and tourism resources in the present work was consistent with the findings of others (ACIL 2009; ABS 2010; Tasmanian Government 2013, 2014; Nichol, Shi & Campi 2013b; Grants Commission 2014; EMDA, Moore Consulting & SCA Marketing 2007b; Felmingham & Wadsley 2008). The valuing of the wood resource in this study was less than others (Mesibov 2002; Timber Workers for Forests 2004; O’Hara, Farley & Smith 2013) but consistent with some (Law 2012; West, cited in Darby 2012). The valuing of the carbon resource in the present thesis was more than others (Keith et al. 2010; Macintosh 2012b; May et al 2012) but the spatial distribution of viable areas proved to be robust under sensitivity analyses. When output multipliers were used to test the sensitivity of development resources, the economic favoring of mineral and wood resources resulted in increases in the area best used for wood production and minor increases in the area best used for mineral production.

5.4.3 Compromise is possible in the Tarkine

The current research demonstrated that it is possible to identify areas for compromise in the Tarkine, and that the level of agreement between conflicting parties can be measured. The extent of potential compromise between conservation and development desires of the participants was determined. The present thesis identified areas that were uncontested and areas that had the greatest conflict. Both the attitudes and preferences that were motivating willingness to compromise and the nature of specific conflicts enacted in the landscape were documented. This thesis has made a significant contribution to the body of knowledge relating to the valuing of the Tarkine by the local community. Previous research has been limited to heritage values mapping (Harries 1995), sustainable development opportunities (Campbell-Ellis 2009), natural values and tourism development mapping (Evans 2011e) and ecosystem services mapping (Williams 2011).

This present thesis makes a substantive contribution to knowledge of the extent and nature of land use conflict in the Tarkine. Conflict has persisted in the Tarkine in a context of deficient knowledge of the extant values, their significance and where values occur in the landscape. This research has a dual purpose: firstly, to objectively and rigorously quantify and commensurate conservation and development values and to identify areas of conflict and potential for compromise, secondly, to provide quality research materials for interested parties to use in potential deliberations and agreement processes.

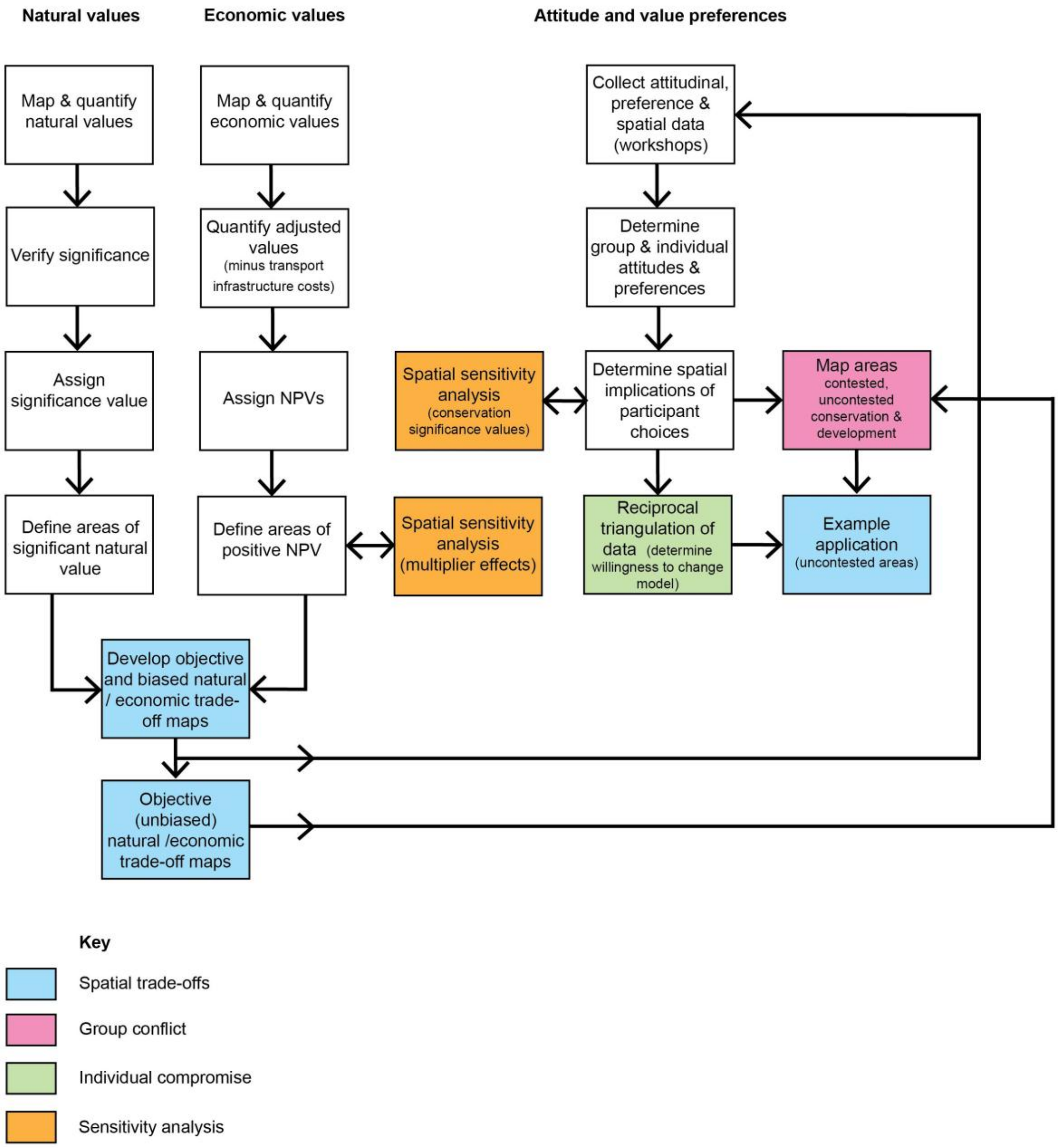

Figure 5.1 – Thesis research process.

5.5 A useful tool for potential land use trade-offs

This thesis is about determining the potential compromise in a region of land dispute by understanding the conflict and assisting land use resolution. The subsequent section of this discussion provides an example of how the research findings could be applied to demonstrate the attributes and inherent flexibility of the database and the general conflict resolution approach. The example is a second iteration of the research findings showing how it could be applied to quantify potential trade-offs between conflicting parties (Figure 5.2).

In order to apply the research findings, the following question is considered, 'what are the areas that are not disputed, either by stakeholders or by the objective analysis, and how might an agreement process proceed whereby parties can trade-off competing interests in areas of conflict?'. The research results from the present thesis were categorised into four elements: a) spatial significance valuing, b) conflict risk, c) social relevance and d) agreement processes. Spatial significance results were the areas for uncontested conservation and development and significance scores for conservation or development. Conflict risk was the extant and potential types of conflict identified in the present research. Social relevance was the factors that directly related to the valuing of the significance scores (e.g. transport infrastructure costs were part of the NPV valuation of the development significance score). Agreement processes were the historical and future potential modes for formalising or gaining community approval for trade-offs of outcomes, either discussed in the PGIS workshops, well known in Tasmanian environmental conflict discourse (Lindenmayer & Franklin 2003; Stewart & Jones 2003; Tasmanian Government 2011a) or known to be applied by others elsewhere (Kashwan 2012; Christiansen 2013; Lacey, Parsons & Moffat 2012).

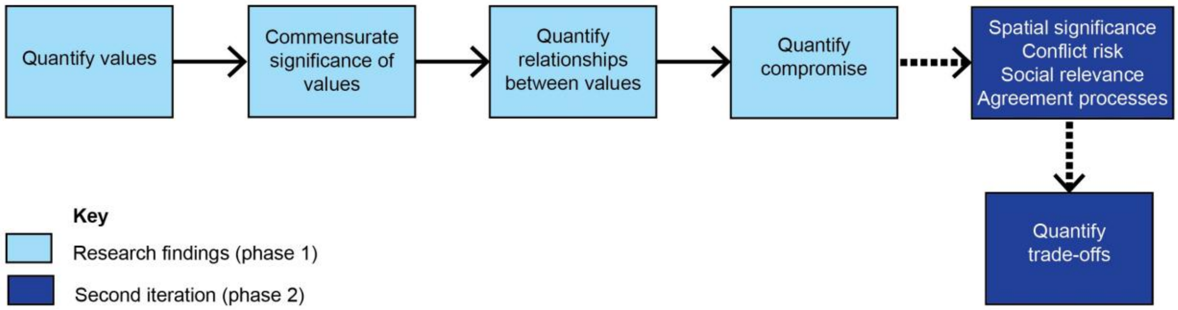

Figure 5.2 – Phase 2 application of research findings.

Conservation and development option continua were derived from the research findings, specifically: significance and distribution of values, conservation and development priorities based on sequential increments starting from uncontested areas, the social relevance of each conservation or development, the conflict risks associated with the attitude groups and conflict trenches and potential agreement processes. An example is provided where key findings of the research are applied in a trade-off context (Figure 5.5a and Figure 5.5b, and Table 5-1, Table 5-2 and Table 5-3). Research participants agreed on areas that were suitable for conservation and development based on their own drawn maps and on map choices generated from an objective value analysis (Figure 5.3). The uncontested conservation and development areas and their significance score are shown in Figure 5.4a and Figure 5.4b.

Each of the options to conserve or develop (Figure 5.5a and Figure 5.5b) starts by using the uncontested areas for conservation or development (Figure 5.4a and Figure 5.4b). From this point, each continuum shows the implications for increased demand for either conservation or development. The increments are based on either the highest significance or smallest coverage of values. For example, although callidendrous rainforest on basalt has a lower significance than rainforest river landscapes, it has a smaller concentrated area and is on the fringe of areas that are uncontested, making it a sensible addition to increasing conservation values, where contiguity is important (Figure 5.5a). Similarly, although MW NPV$/ha > 5M (with multiplier) has a higher value than MW NPV$/ha > 1M (non-multiplier), it was used as a number 4 in the development sequence as it provided logical clustering around existing areas of uncontested development close to supporting transport infrastructure (Figure 5.5b).

The data are used here to understand what logical progressive land use pattern may evolve as demands for either conservation or development increases and what the consequences are of such choices. A flow chart shows the logical decision making process for determining each conservation or development option on each continuum (Figure 5.7).

Once the conservation and development parameters and implications are defined according to each conservation or development sequence (Table 5-1 and Table 5-2), both matrices can be combined (Table 5-3) whereby trade-offs are made by either interest in order to meet specific targets (Figure 5.6).

The conservation and development matrices (Table 5-1 and Table 5-2) illustrate the multiplicity of the issues that might be implicated by increasing desires for conservation or development and the spatial and social outcomes that may be gained or forfeited as a result of trade-off outcomes. The combined matrix (Table 5-3) demonstrates a balanced approach to trade-off negotiations and could be used as a tool for workshop discussions, to aid debate towards deciding potential mutually acceptable trade-offs and determining their impacts. The combined matrix could be used whereby trade-offs could be made in a biased sense (e.g. a trade-off could be considered where desires of development 2 are traded for conservation 1, only if another area is traded for conservation 2 and development 1). This might be a useful negotiation tool for important areas or issues where there is a conflict trench or negotiation stalemate. It is acknowledged however, that natural limits to certain trade-offs exist, for which conflictors may operate within. For example, the minimum habitat area required to support a viable population of species or the footprint of a prospective VHMS mineral deposit. Thus real constraints are present and not all potential trade-off options may be feasible.

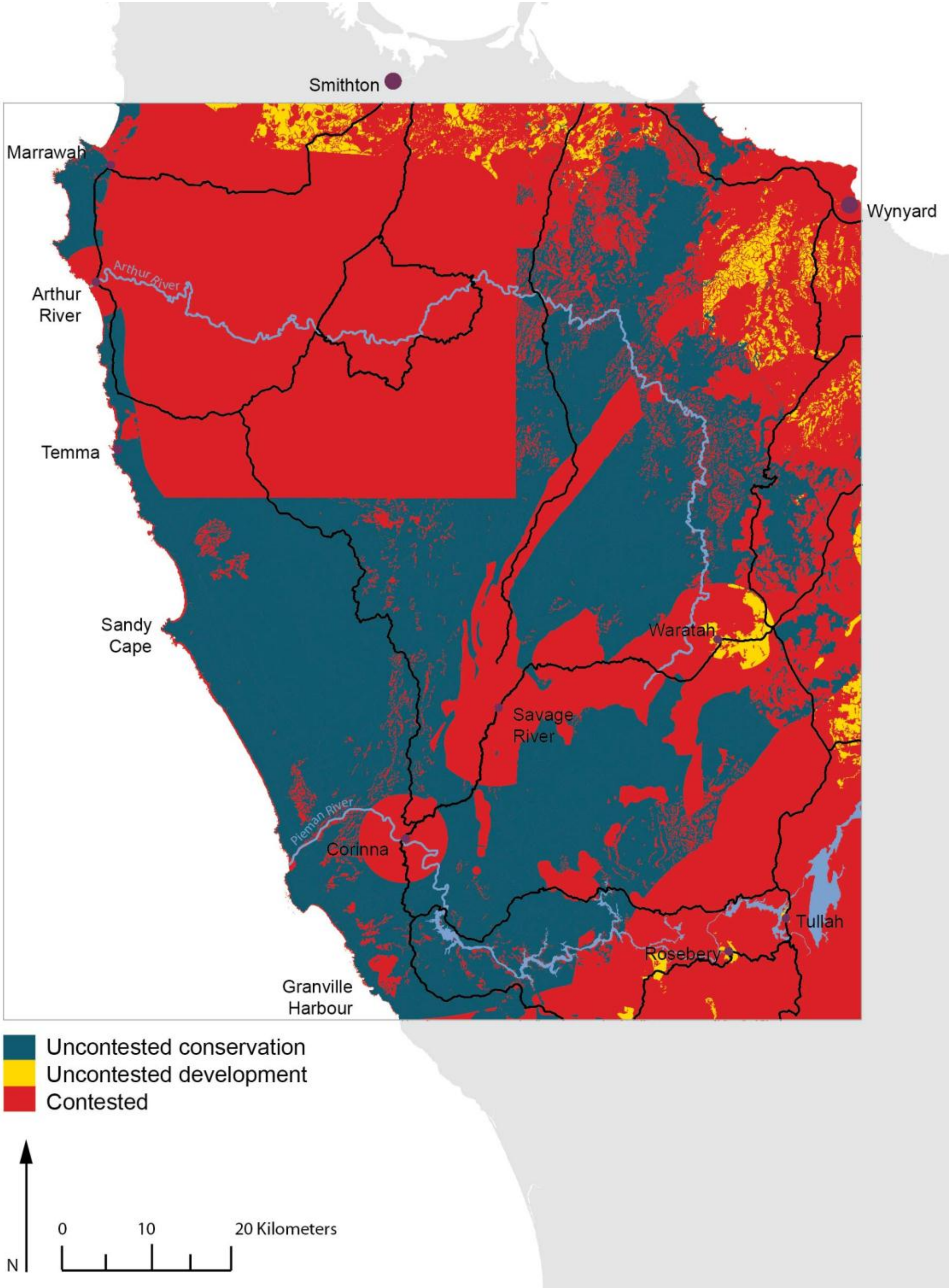

Figure 5.3 – Areas of uncontested conservation and development.

(From participant selected and drawn maps).

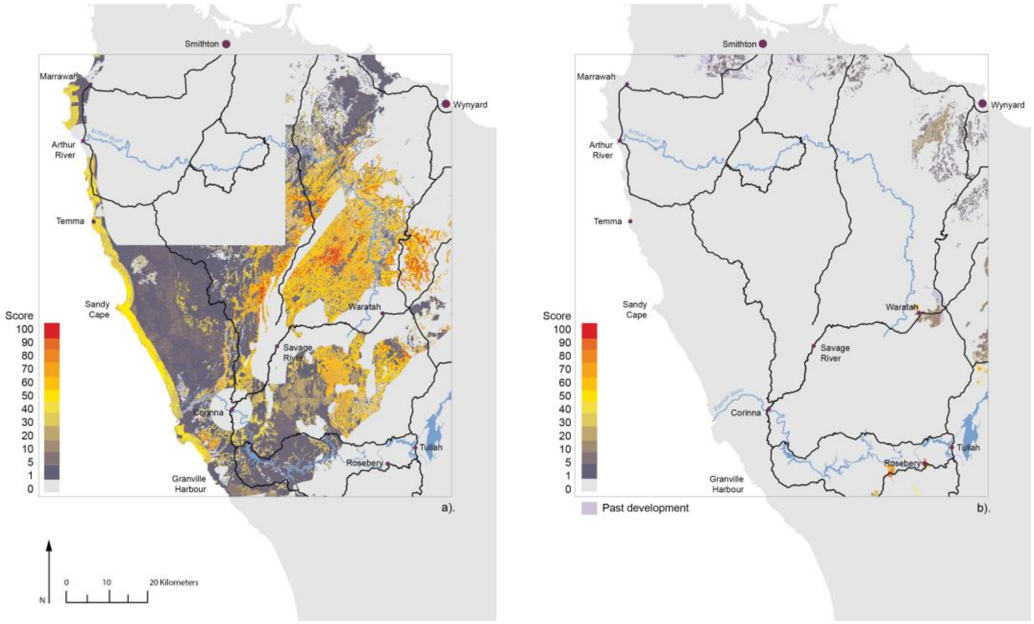

Figure 5.4 – Scored areas of uncontested conservation and development.

(Areas of uncontested conservation and development from participant selected and drawn maps (score indicates the adjusted significance value a) conservation significance and b) economic significance)).

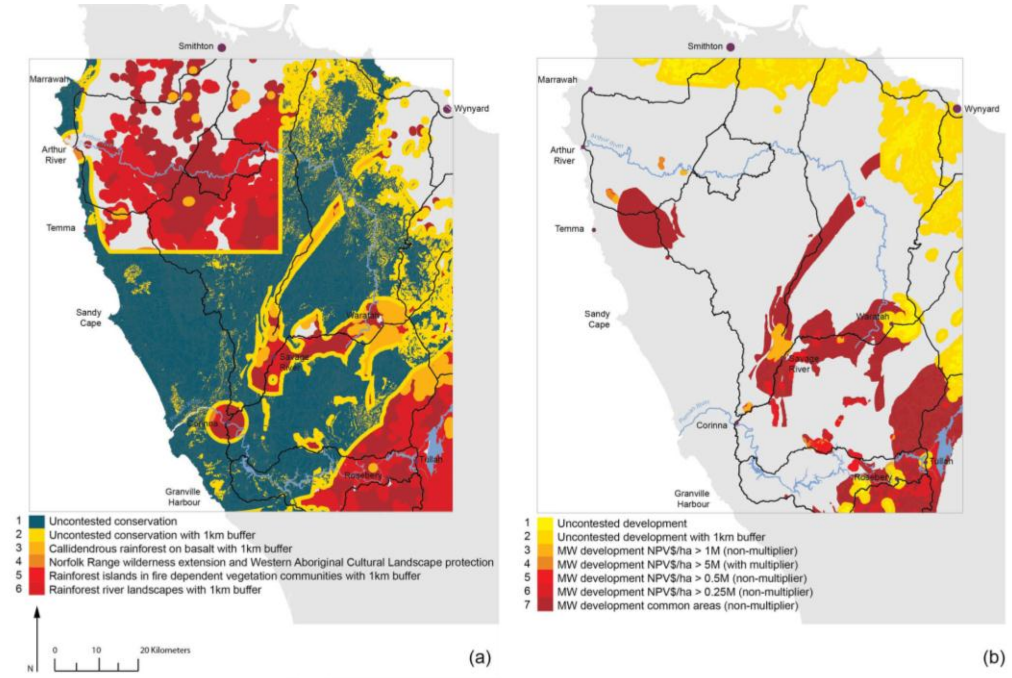

Figure 5.5 – Potential conservation and development continua.

Potential a) conservation and b) development continua (all choices after action 1 involve areas that would be in contestation with conservation or development values).

Table 5-1 – Conservation continuum matrix.

On the left side of the matrix conservation is initially confined to agreed uncontested areas then expanded progressively toward the right side of the matrix providing extensive conservation and increasing conflict. Numbers for conservation choices (1 to 6) are shown on the development continua map (Figure 5.4a).

	Conservation continuum					
	Limited conservation	**Increasing conservation**	**Increasing conservation**	**Increasing conservation**	**Increasing conservation**	**Extensive conservation**
Conservation choices	Only conserve areas where conservation values are uncontested (1).	Increase conservation to include a 1 km buffer to areas of uncontested conservation (2).	Increase conservation to include callidendrous rainforest on basalt values with a 1 km buffer (3).	Increase conservation to include Norfolk Range wilderness extension and implement Aboriginal cultural heritage protection within the Western Aboriginal Cultural Landscape boundary (4).	Increase conservation to include rainforest islands in fire dependent vegetation communities with a 1 km buffer (5).	Increase conservation to include rainforest river landscapes with a 1 km buffer (6).
Values being conserved	Portions of biodiversity, rainforest and aesthetic values conserved.	Norfolk Range wilderness area maintained and minimal increases to areas of biodiversity, rainforest and aesthetic values.	Upper Savage River wilderness area maintained, Pipeline Corridor conserved and callidendrous rainforest on basalt values conserved.	Norfolk Range wilderness area extended and coastal Aboriginal cultural heritage conserved.	Rainforest islands in fire dependent vegetation communities and inland Aboriginal cultural heritage conserved.	Meredith Range, Bertha and Sumac wilderness areas conserved, rainforest river landscapes conserved, largest contiguous area of rainforest and rainforest river landscapes conserved. Large areas of biodiversity conserved.
Social relevance	Existing transport infrastructure to service levels of conservation.	Introduce strategies for sustainable tourism and tourism	Invest in special research areas for observing rainforest	Introduce additional IPAs, joint management with Aboriginal community	Reserve status adjustments to enable conservation. Potential for social enterprise for carbon	Increased potential for carbon trading and Aboriginal self-determination.

	Investment in fire management and carbon stock protection required.	industry certainty.	and wilderness values.	and land hand backs to Aboriginal community.	sequestration and investment in the existing road infrastructure to support tourism development at Corinna.	
Conflict risk	Broad community debate and conflict between those who wish to conserve the Tarkine and those who wish to see it developed. Arguments about perceived conservation values and listing status.	Broad community debate and conflict between those who wish to conserve the Tarkine and those who wish to see it developed. Arguments about perceived conservation values and listing status.	Mining interests and environmentalist conflict over restrictions for extensions of some existing operations and no access to future prospective areas (Pipeline Corridor).	ORV interests, Aboriginals and environmentalists in conflict over 4WD track closures. Shack owners in conflict with environmentalists and Aboriginal communities over increased heritage protection measures.	Increased conflict between mining, forestry interests and broad community with environmentalists over restrictions on mining of prospective remote deposits and areas of high prospective geological mineral potential to the SE and wood resources in the north.	Intensified conflict between mining, forestry interests and broad community with environmentalists over increased restrictions on mining of prospective remote deposits and areas of high prospective geological mineral potential to the SE and wood resources in the north.
Agreement processes	Agreement to preclude mining and timber development. Reserve status adjustments to preclude mining and timber harvesting. Broad active community participation and engagement may be required to assist in land use resolution and implementation of a regional conservation plan.	Agreement to preclude mining and timber development. Reserve status adjustments to preclude mining and timber harvesting. Broad active community participation and engagement may be required to assist in land use resolution and implementation of a regional conservation plan.	Agreement to preclude mining development. Reserve status adjustments to preclude mining. Broad active community participation and engagement may be required to assist in land use resolution and implementation of a regional conservation plan.	Bill of rights to secure ongoing protection of wilderness areas and buffers. Special provisions (joint consultative processes) to enable self-determination of cultural lands and practices for the Aboriginal community.	WHA listing, provisions for excluding development. Broad active community participation and engagement may be required to assist in land use resolution and implementation of a regional conservation plan.	Bill of rights to secure ongoing protection of all wilderness areas and buffers. Ongoing broad active community participation and engagement to assist in land use resolution and implementation of a regional conservation plan.

Table 5-2 – Development continuum matrix.

On the left side of the matrix development is initially confined to agreed uncontested areas then expanded progressively toward the right side of the matrix providing extensive development and increasing conflict. Numbers for development choices (1 to 7) are shown on the development continua map (Figure 5.4b).

	Development continuum						
	Limited development	**Increasing development**	**Increasing development**	**Increasing development**	**Increasing development**	**Increasing development**	**Extensive development**
Development choices	Only develop areas where development values are uncontested (1).	Increase development to include a 1 km buffer to areas of uncontested development (2).	Increase development to include MW values where NPV $/ha >1M using non-multiplier quantification*[*] (3).	Increase development to include MW values where NPV $/ha >5M using multiplier quantification* (4).	Increase development to include MW values where NPV $/ha >0.5M using non-multiplier quantification* (5).	Increase development to include MW values where NPV $/ha >0.25M using non-multiplier quantification* (6).	Increase development to include MW polygons that are common to non-multiplier and multiplier options* (7).
Values being developed	Mostly wood resources in the north with small areas of existing mineral deposits.	Mostly wood resources in the north with small areas of existing mineral deposits.	Mostly mineral resources involving existing mineral deposits and limited new remote deposits.	Mostly mineral resources involving existing mineral deposits and limited new remote deposits.	Mostly mineral resources including prospective speculative deposits.	Mostly mineral resources including prospective speculative deposits and areas of prospective geological mineral potential.	Mostly areas of prospective geological mineral potential with small areas of wood resources.
Social		Existing transport infrastructure to	Sporadic traffic increases from new	Increased traffic impacts from new	HPV upgrades and new road	Increasing HPV upgrades and new	Regional transport infrastructure

[*] * Where a 7% discount rate p.a. over 10 years in applied.

relevance	Existing transport infrastructure to service levels of development.	service levels of development.	remote deposits.	and consolidated remote deposits.	construction to increasingly remote deposits, increased operational costs on major transport infrastructure.	road construction to additional remote deposits, increased operational costs on major transport infrastructure.	investment including upgrade to Melba rail line, and options for access to Pipeline Corridor.
Conflict risk	Localised clashes between communities and Forestry operations.	Localised clashes between communities and Forestry operations.	Conservationist and mining company conflict over new remote deposits, local communities and increased traffic impacts.	Conservationist and mining company conflict over new remote deposits, local communities and increased traffic impacts.	Increased conflict between conservationist and mining company over prospective remote deposits, and new roading impacts into wilderness buffers.	Increased conflict between conservationist and mining company over prospective remote deposits, and new roading impacts into wilderness buffers.	Conflict with high conservation values particularly around the Pipeline Corridor and wilderness buffers in the Meredith Range. Conflict with tourists and high visual impacts from main roads.
Agreement processes	Existing governance conditions allowing development.	Reserve status may have to be adjusted to allow some logging operations. Forest operators may consider implementing sustainable development practices (SD), corporate social responsibility (CSR) and attaining social licence to operate (SLO).	Statutory licence arrangements may have to be improved to prevent the risk of acid mine drainage, royalty and rehabilitation bond defaults and negative environmental impacts.	Cost-benefit analysis of transport infrastructure investment may be required to plan for appropriate investment, consolidation of improved statutory licence arrangements and implementation and mining companies may have to demonstrate CSR by delivering SD	Ongoing cost-benefit analysis of transport infrastructure investment, mining companies to provide SLO and avoid negative impacts on high conservation values. Broad active community participation and engagement may be required to assist in land use resolution and implementation of a regional	Regional transport infrastructure plan with social licence to implement, mining companies to provide SLO (indirect) and avoid negative impacts on high conservation values. Ongoing broad active community participation and engagement to assist in land use resolution and implementation of a	Regional transport infrastructure plan with social licence to implement, mining companies to provide SLO (indirect) and avoid negative impacts on commensurate World Heritage values. Ongoing broad active community participation and engagement to assist in land use

				outcomes.	development plan.	regional development plan.	resolution and implementation of a regional development plan and resolution of conservation significance status of the Tarkine as a whole.

Table 5-3 – Conservation and development trade-off options.

Based on combinations of development and conservation choices (1 to 6).

	Conservation and development choice combinations					
	1/1	**2/2**	**3/3**	**4/4**	**5/5**	**6/6**
Conservation and development trade-off options	Conserve and develop uncontested areas only.	Create Norfolk Range National Park and allow wood resources to the north to be harvested.	Extend Savage River National Park to include Pipeline Corridor, create Meredith Range National Park and allow mines close to existing roads and southern edge of the Meredith Range to be mined.	Extend Norfolk Range National Park and create Western Aboriginal Cultural Landscape National Park and allow development of existing remote mines in the north that clash with rainforest river landscape values and rainforest islands in fire dependent vegetation communities.	Protect rainforest river landscapes in the north and allow mining of rainforest river landscapes around Rosebery / Tullah.	Protect all wilderness areas and buffers and allow the development of prospective deposits that do not impact on wilderness values.
Agreement processes	Broad active community participation and engagement in the creation of regional conservation and development plan.	Broad active community participation and engagement in the creation of regional conservation and development plan. Forestry operations to demonstrate SD, CSR and SLO.	Statutory improvements to licence arrangements for the mining industry. Adjustments to reserve status. Broad active community participation and engagement in the creation of regional conservation and development plan.	Cost-benefit analysis of transport infrastructure investment. Mining companies to demonstrate SD, CSR and SLO. Bill of rights to secure ongoing protection of wilderness areas and buffers and protection of Aboriginal cultural heritage. Broad active community participation and engagement in the	Cost-benefit analysis of transport infrastructure investment. Mining companies to demonstrate SD, CSR and SLO (indirect). Bill of rights to secure ongoing protection of Aboriginal cultural heritage and landscapes. State sanctioned request for consideration of World Heritage Listing agreed conserved areas. Broad active community	Regional transport infrastructure plan. Mining companies to demonstrate SD, CSR and SLO (indirect). Bill of rights to secure ongoing protection of Aboriginal cultural heritage and landscapes. Ongoing protection of World Heritage Listed values. Broad active community

				creation of regional conservation and development plan.	participation and engagement in the creation of regional conservation and development plan.	participation and engagement in the creation of regional conservation and development plan.
Social relevance	Invest in fire management and carbon stick protection.	Tourism industry certainty and demonstrated SD.	Invest in special research areas in rainforest and wilderness values.	IPAs, joint management, land hand backs and transport infrastructure investment.	HPV improvements, investment in transport infrastructure and carbon trading social enterprise.	Carbon trading consolidation, Aboriginal self-determination and transport infrastructure improvements.

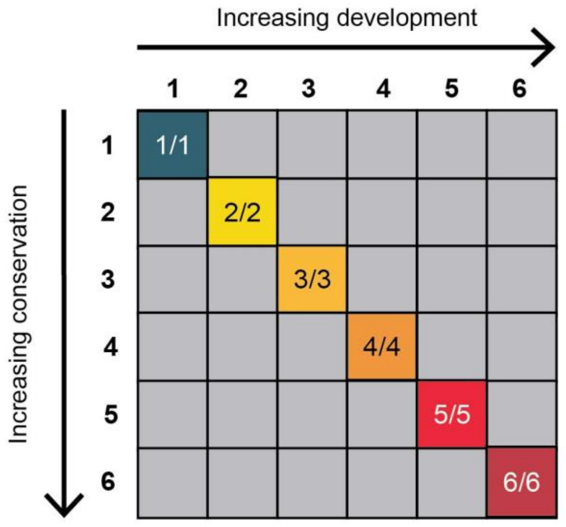

Figure 5.6 – Potential trade-off matrix between conservation and development options.

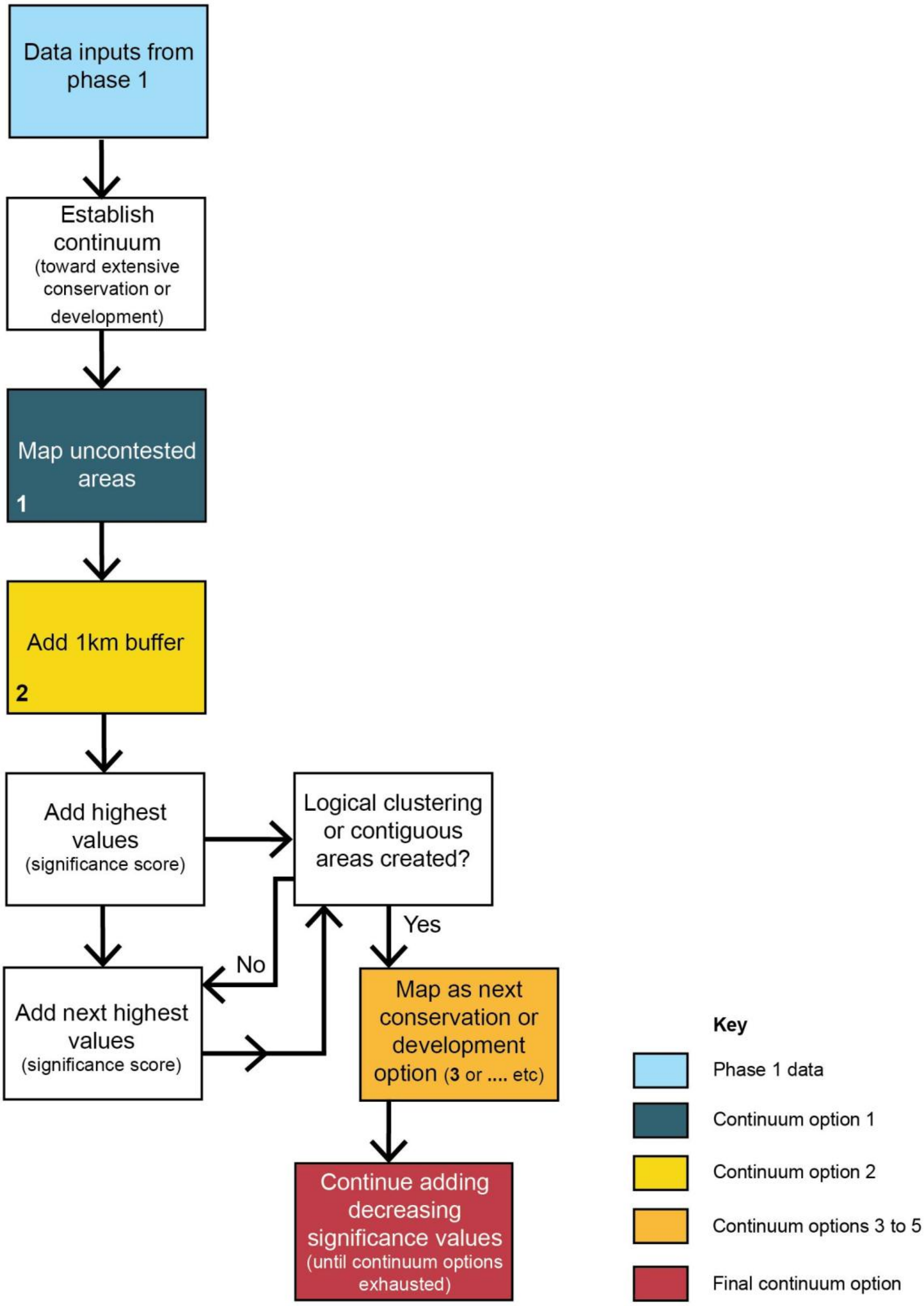

Figure 5.7 – Application of thesis.

(Using research process and outcomes to determine continuum options).

5.6 Methodoligical relevance

The original hypothesis of this thesis was to determine if conflicting parties could resolve their disagreements about conservation and development through exposure to independent information and talking through the conflict using group participation methods. Historical agreement models such as the Salamanca Agreement (Mercer 2000; Patmore 2000) were considered. The research concept was to determine whether conflicting parties could agree to compromise and settle on sequential levels of conservation and development in the Tarkine. That is, could they reach agreement on areas for conservation and development in perpetuity and a compromise sequence for the contested areas? It became clear that this scale of investigation was not possible to achieve within the timeframe of this PhD. The purpose was best served by focusing on creating an analytical framework that would provide information to interested people participating in decision-making processes at any stage of conflict negotiations.

The methodological approach used in the present thesis was novel. It used a systematic method of progressively investigating each research objective, using the results from each proceeding research phase to inform the next. The research progressed from investigating the natural and economic values, quantifying their significance, determining their optimal land use, elucidating the attitudes toward conflict to the climax of scoping the potential conflict compromise. Multiple exercises of reciprocal triangulation were conducted during each research phase. For example, reciprocal triangulation was conducted between spatial and non-spatial, *a priori* and *a posteriori*, significance and importance of values and individual and group attitudinal preferences. This reciprocal triangulation involved multiple data, multiple methods and integrated different method approaches. This multi-stage triangulation brought to life the varied voices within the biocentric and anthropocentric spectra and their relationships to conservation and economic land use significance.

The practical example of how the research may be applied through a second iteration and engagement process demonstrates the possibility of future outcomes when indefinite / ongoing reciprocal triangulation is used. Indefinite / ongoing reciprocal triangulation is an ethnomethodological approach used to expose multiple realities, their reflexivity and differing biographical, physical and temporal perspectives (Hammersley 2008). Circourel et al., cited in Hammersley (2008) argues that the reciprocal viewpoint of social interactions is not static and therefore requires multiple reciprocal interpretations to elucidate its full meaning. This approach has been used in the practical example in order to demonstrate how potential diverging interpretations of individuals' viewpoints may be used in conflict resolution negotiations.

The strength of the methodology in the present thesis is that each research phase component is valid within its own right and can be used by decision makers. For example, if conservation management were a key consideration for decision makers, then the results from chapter two (assessing the heritage importance of conservation values in the Tarkine) could be considered. Similarly, if optimal economic land use were to be deliberated by decision makers, the results from chapter three (determining the pattern of optimal economic use in the Tarkine) may be of interest. Further, decision makers could consider chapter four (conflict in the Tarkine: triangulation of group attitudes, value preferences and conflict scenarios using PGIS processes) if social / political aspects of land use decisions were relevant. In this way, each research objective outcome is both independent and integrated into the research conclusions of the potential for conflict compromise.

The research from this thesis may have practical implications for understanding conflict and assisting in land use resolution in contested regional settings elsewhere and may be useful in expanding the knowledge for other PGIS processes. As the PGIS workshop format delivered an unexpectedly high level of willingness to compromise amongst participants, it would be advantageous to further test the hypothesis that informed discussion of values leads to increased willingness to compromise. Given that the workshop format in this study included multiple options to select unbiased, biased and to draw maps (which were central tasks to measuring willingness to compromise) over several hours, allowing participants to change their mind as discussions went on, it might be valuable to understand more how these elements may contribute to productive and conciliatory deliberations. Whilst the PGIS workshop format was successful, it was viewed as culturally inappropriate for groups of Tasmanian Aborigines. This raises questions about how to engage with the Tasmanian Aboriginal community generally beyond individual interviews, to ensure appropriate representation of Aboriginal community voices and to capture the influence of group deliberations on personal views.

The research may have practical implications for providing new ways to map and commensurate values in GIS. The simple significance scoring system (0 to 100) allowed easy operationalisation of data, providing multiple ways to calculate trade-offs between development priorities, resources and natural values through addition, subtraction and multiplication of scores. This scoring approach provides a flexible database whereby inputs can be changed in the future by altering fields using a multiplication factor. Once established, the GIS database facilitated the investigation of spatial implications of varying significance value levels or levels of agreement for land use options.

Chapter 6 Conclusions and further research

6.1 Introduction

Ecosystems are complex adaptive systems that are subject to changing environmental conditions and human impacts. The resilience and distribution of ecosystems continues to decline as global demand for natural resources force land use change and cause environmental degradation and conflict. Optimal land use that considers both the significance of ecosystems and the sustainable human consumption of natural resources is required. Land use change and environmental conflict are influenced by complex socio-economic factors and necessitate systematic resolution practices that address deep disagreement on values.

Environmental conflict resolution approaches such as participatory GIS (PGIS), engagement processes, elucidation of values, social surveys, conflict characterisation, conflict management processes, conflict mapping, economic values mapping and land use trade-offs have been used in the past. Whilst previous research has provided partial approaches to land use conflict resolution, there are no systematic methods for combining participatory and scientific approaches. This thesis fills this research gap by providing a systematic quantification of optimal land use and potential conflict compromise approach that combines multiple methods, anticipates and defines the characteristics of conflict, responds to local conditions and integrates attitudes, preferences and economic values.

6.2 Research conclusions

The research begins by quantifying the heritage importance of conservation values in the Tarkine through determining their level of significance using legal recognition of importance, area in relation to Tasmania, Australia and the world, rarity, and distinctiveness. The thesis finds that some conservation values are globally significant and may meet criteria for World Heritage listing (Aboriginal cultural heritage, coastal interdigitation, rainforest river landscapes, wild Dasyuridae habitats), that some are likely to increase in significance over time (Aboriginal cultural heritage, biodiversity and wilderness) and that the international significance of the Aboriginal cultural landscape in the Tarkine has not been fully determined.

Once the importance of conservation values are quantified and mapped, the potential patterns of optimal economic land use in the Tarkine are determined by calculating the spatial patterns of net present value for alternative uses. Cost benefit analysis (CBA), variable discount rates, time frames and output multipliers are used to calculate economic values. The thesis finds that there is high economic potential for carbon and tourism development in the Tarkine with localised mining activity. However, the application of output multipliers change the results creating large areas of forest with greater economic value than tourism and carbon combined.

Having determined both the objective importance of conservation values and their optimal land use, the study then discusses the subjective valuing and trade-offs between conservation and development desires of the research participants. A novel reciprocal triangulation of data on attitudes and PGIS was used to identify the nature and distribution of conflict in the Tarkine. This thesis finds that conflict is multidimensional; that informed discussion of values leads to increased willingness to compromise potential outcomes; and, that variation in such willingness is predictable. There is an inclination for most respondents to increase their readiness to compromise as a result of increased understanding of the values of the Tarkine. Participants with deep personal place connections and/or cultural identity are not easily influenced by the PGIS process and are least willing to compromise.

The study concludes by reviewing the importance and meaning of the research findings and their contribution to scholarly work. A practical example suggests a way forward to resolve conflict in the Tarkine through applying a second iteration of the research findings to quantify future trade-offs and advance conflict resolution processes.

Whilst this thesis is place specific, the study contributes to scholarly knowledge by demonstrating how potential compromise in any region of land dispute can be reached by understanding firstly the extent and nature of conflict and secondly the scope for land use resolution and / or compromise. This thesis has combined well established PGIS, attitude and value preference, conservation significance and economic valuation techniques in a new way that may be an improvement on current land use valuation methods.

6.3 Limitations of the research

While the present research demonstrated a temporal valuing of the Tarkine in 2013, the relative values of some of the research inputs may change over time more than others. For example, the economic value of the development resources will fluctuate over time, mineral prices will vary and carbon markets may increase in certainty, thus, the CBA and spatial distribution of particular development priorities may vary. Also, the relative significance of some natural values may increase over time with their increasing global scarcity. Social behaviours around ORV on middens may change and the number of tourists visiting Aboriginal heritage sites may increase. Despite this, some spatial elements that make up the foundational valuing of the database may be more resistant to change, have inherent values and therefore remain constant in their distribution compared to others. For example, abiotic values such as geological mineral potential and coastal interdigitation will not change. The spatially dominant values such as vegetation communities are unlikely to experience broad scale change. The Aboriginal archaeological sites (although they are under threat of damage and reduction in extent and quality) will not disappear. Therefore it can be concluded that whilst this thesis provides a snapshot of the valuing of the Tarkine in 2013, it retains a fundamental robustness inherent in the base data used making it relevant beyond 2013.

6.4 Future research

This thesis presents a land use compromise tool that conflict actors could use. The conflict resolution processes and quality of data inputs discussed and presented in this thesis could be improved by future research. Such future research may include detailed cultural mapping, refined economic analysis and further conflict resolution agreement processes.

Appropriate methods for mapping the Aboriginal cultural heritage values of the Tarkine would be required in order to sufficiently measure its international significance. Processes that empower the Tasmanian Aboriginal community to conduct and control such research would need to be defined and sanctioned. Aboriginal self-determination, land and social justice issues may need to be integral to the research processes, along with future options for land management such as IPAs, joint management and land hand backs. Future research as described above may provide vital inputs for the development of a management plan for the recently National Heritage listed Western Tasmanian Aboriginal Cultural Landscape and insights into improving ongoing damage to Aboriginal cultural heritage values on the Tarkine coast (e.g. ORV destruction of middens). The research suggested here may offer appropriate methodologies for extending Aboriginal cultural heritage mapping to the TWWHA, thus creating a complete representation of the nature and extent of Aboriginal cultural values in the Tasmanian landscape.

A more refined economic analysis of the wood, minerals, tourism and carbon resources would improve the valuation of the development resources and thus enhance the quality of the development significance scoring and the GIS database. Such research may include quantifying the economic contribution of down stream processing of the wood resource and the extent of regional leakage from mining revenues. Congruent with such analysis would be the additional lifecycle cost of bridges to produce accurate NPVs that reflect the real cost of remote development and traffic impacts on major routes. Research that can help elucidate policy regimes under which the carbon potential of the region could be realised would progress the level of certainty for the development priorities and would increase the confidence of potentially large-scale trade-off options. Defining the sustainability and expected visitor growth of tourism would complement carbon market research, particularly in conjunction with old growth rainforest values.

In this thesis, the Pipeline Corridor was the most contested area as it contained the highest number of competing development resources and conflicting participant valuing. The two major competing values were mineral prospectivity and rainforest values. The spatial analysis in this thesis indicated a low to mid range of geological mineral potential scores (28 to 70), two historic mining fields and 553 geological testing sample sites within 1 to 2.2km of the Pipeline Road, indicating a reasonable level of past exploration activity. Highest geological mineral potential scores (49 to 70) were confined to an area within 8 km north of the existing Savage River Mine. The Pipeline Corridor contains some of the DRM resource, which is unavailable for logging. The decision not to allow logging in the Pipeline Corridor is a political one, as is the decision to allow mining in the same area. This area is highly contested for this reason. Further research that defines the mineral potential of the Pipeline Corridor more specifically would assist in determining the acuteness of the conflict between conservation and development interests. As the Pipeline Corridor represents a difficult grey area for compromise trade-offs, future research that would assist in negotiating compromise agreements such as legal mechanisms to deliver surety or suitability of a regional conservation / development management plan may be of use. Such research may have the potential to guide conservation or development actions over time, particularly for highly contested areas.

Future conflict resolution processes could be explored whereby the PGIS methodology used in this thesis could be replicated in a second stage of negotiations between conflicting parties using conservation and development continua matrices to prompt discussion about specific trade-offs. A second iteration of the research from this thesis could test the usefulness of the trade-off sequence. Firstly, participants could design the conservation and development options continua (provide inputs for defining the spatial significance, conflict risk, social relevance and agreement processes) based on objective information provided by PGIS processes. Secondly, participants could map their trade-off preferences during PGIS workshops. Thirdly, participants could discuss and attempt to reach consensus for trade-off options using the materials produced and objective information provided during PGIS processes.

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Plates

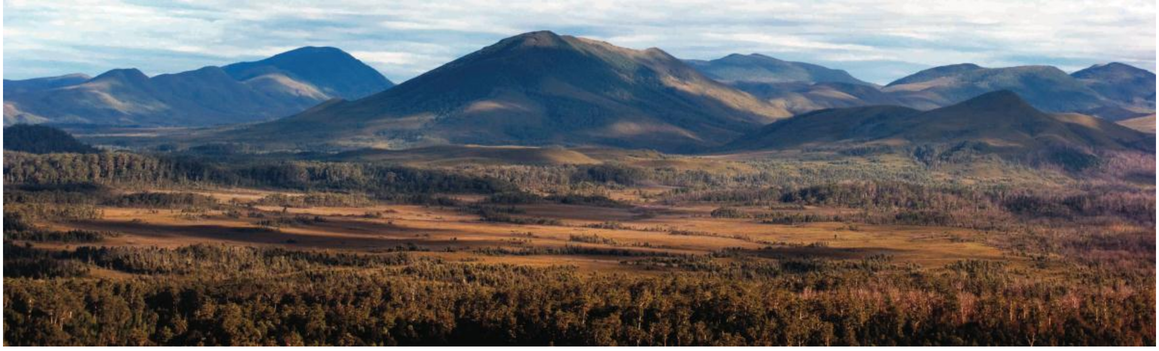

Plate 1 - Aboriginal cultural landscape, Norfolk range wilderness (Archer 2010a)

Plate 2 - Aboriginal midden, Tarkine coast (Blakers 2005a)

Plate 3 - Spring flowers of Austral noonflower, Tarkine Tasmania (Dombrovskis 2006)

Plate 4 - Tarkine Coast (Bell 2013)

Plate 5 - *Sarcophilus harrisii* (Evans 2011d)

Plate 6 – *Astacopsis gouldi* (Evans 2011b)

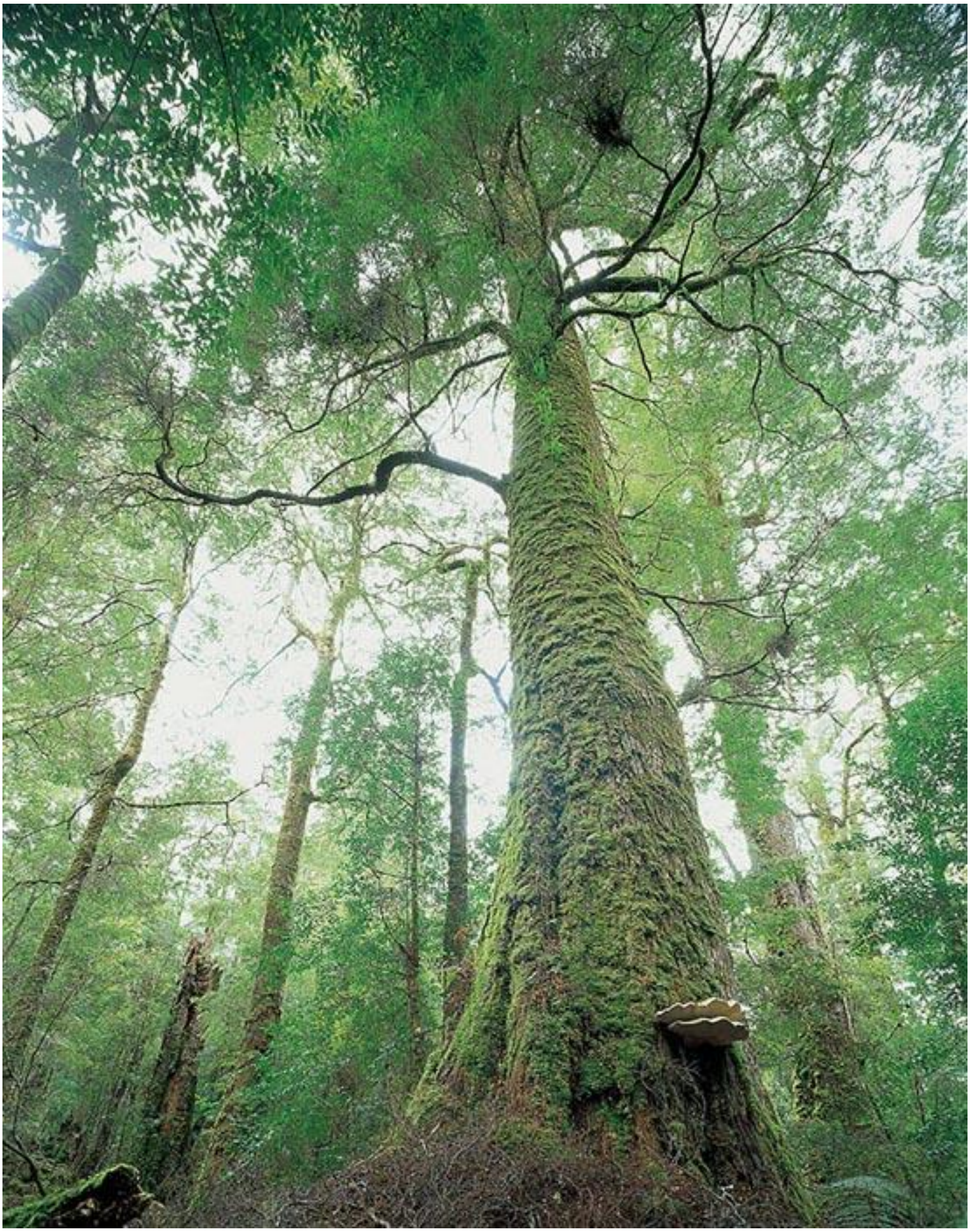

Plate 7 – Myrtle at the Pipeline Corridor (Blakers 2007)

Plate 8 – Twin Sassafras, *Atherosperma moschatum* (Mead 2004)

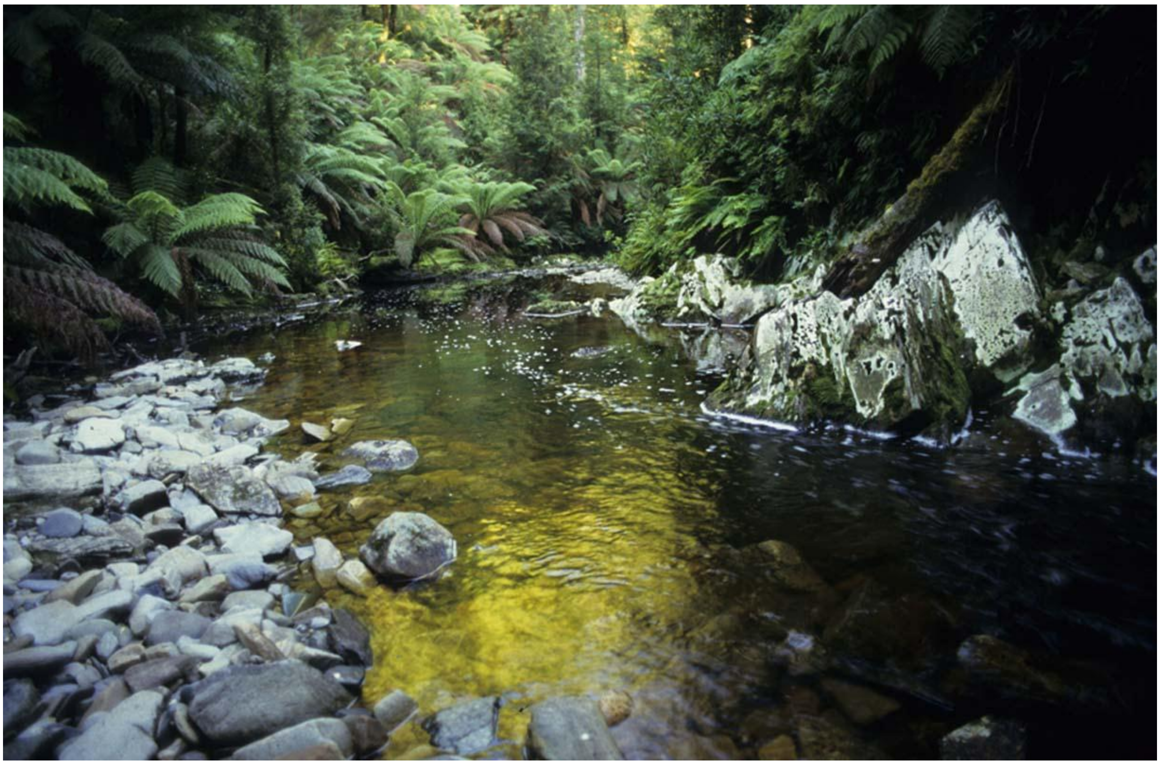

Plate 9 - Rapid River, Tarkine (Blakers 2008)

Plate 10 - Donaldson River, Tarkine (Evans 2011c)

Plate 11 - Tarkine from Mt Donaldson, view north over Australia’s largest cool temperate rainforest (Townsend 2004)

Plate 12 – Rainforest, Savage River wilderness (Archer 2011c).

Plate 13 - Meredith Range (Blakers 2005b)

Plate 14 – Aboriginal artefact and quarry site, Tarkine coast (Archer 2011a)

Plate 15 – Aboriginal grinding stone, Tarkine coast (Evans 2011a)

Plate 16 – Savage River mine (Evans 2012a)

Plate 17 – Savage River mine (Mercury 2015)

Plate 18 – Melba rail line, transporting minerals from Rosebery to the Burnie port (Kinnane 2015)

Plate 19 – Melba rail line crossing the Rosebery Creek (Bluedawe 2009)

Plate 20 – Port Latta loading facility (Magnet 2015)

Plate 21 – Port Latta processing plant (Spies 2014)

Plate 22 – Savage River pipeline suspension bridge supporting pipeline to Port Latta (Evans 2012b)

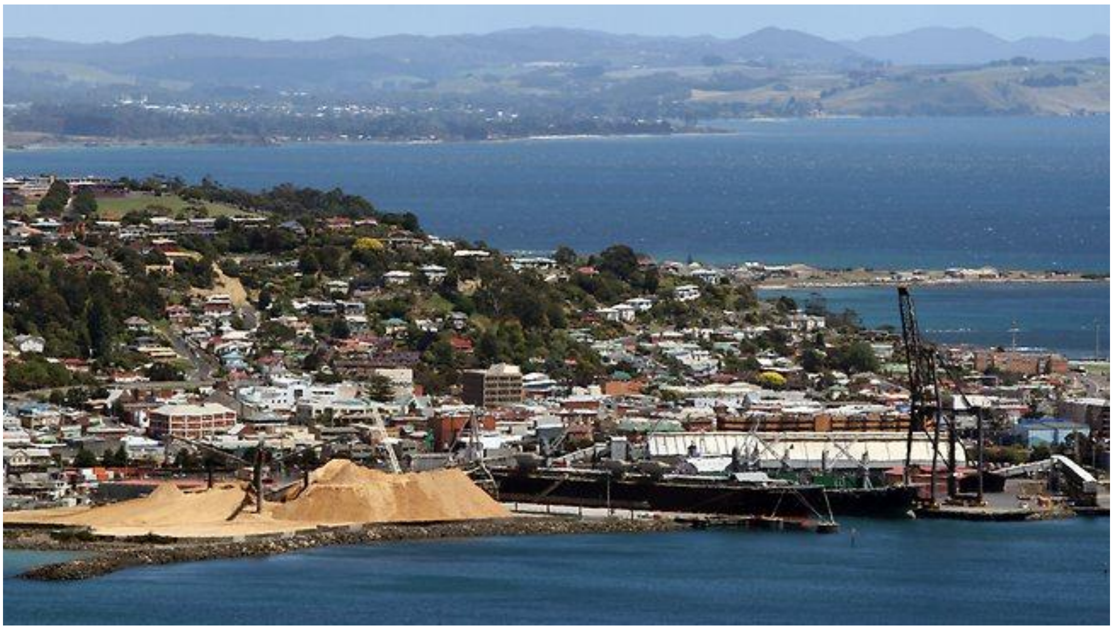

Plate 23 – Burnie port woodchip loading facility (Kidd 2014)

Plate 24 – Forest harvesting, Tarkine logging coupe (Johnson 2015)

Plate 25 – Log haulage, Bass Highway (Evans 2014)

Plate 26 – Nature based tourism in the Tarkine (Archer 2011b)

Plate 27 – Tarkine Hotel, Corinna (The Invermay Press 2010)

Plate 28 – Carbon rich forests, Tarkine (Blakers 2015)

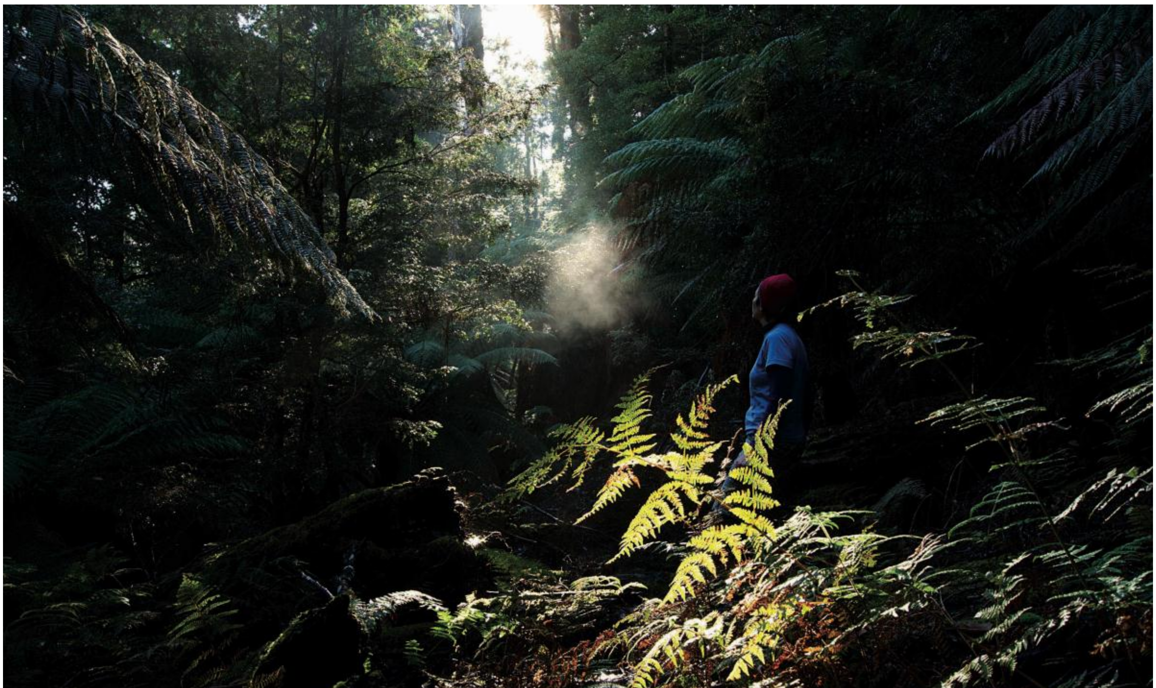

Plate 29 – Carbon rich forests, Tarkine (Archer 2010b)

Chapter 7 Appendix

7.1 Conservation significance sensitivity analysis

7.1.1 Introduction

In geographic information systems (GIS) tools, SAW methods provides a proportional linear transformation of the raw data (Söylemez & Düzgün 2009). The application of SAW methods in GIS assumes linearity and additivity of attributes, which has been criticised as potentially leading to inadequate representation of values (Malczewski 1999). Sensitivity analyses can be used to determine the effect of change of weights on final SAW scores (Memariani, Amini & Alinezhad 2009; Johnston & Graham 2013) and are useful where there is uncertainty in defining the importance of values or procedures for assigning weights are ad hoc (Malczewski 1999; Ozturk & Batuk 2011). The *a priori* significance scoring for conservation values in this thesis are therefore tested for sensitivity against the *a posteriori* significance scoring provided by the PGIS participants.

7.1.2 Methods

The Likert scores (range of 1 to 7) that participants placed for the importance of each conservation value (for Tasmanian importance of the Tarkine, why places were favoured and the most important issues) (Table 4-2) were totalled. The percentage that the total score represented for the maximum possible score for each conservation value (Aboriginal heritage, biodiversity, aesthetics, rainforest river landscapes, wilderness and rainforest) was calculated (e.g. the total participant scores for the importance of biodiversity values was 276, which equated to 87.62% of a total possible maximum score of 315). This procedure was repeated for each conservation value (Figure 7.1b, Table 7-1).

Mean scores were calculated for the *a priori* (independent) conservation significance scores for all polygons for each conservation value (e.g. all polygons that had biodiversity scores were selected in GIS and average score for all polygons was calculated). These mean *a priori* significance scores were compared to the participant mean significance scores using a matrix plot where conservation values placements were compared on the two axes for clustering and tested using simple linear regression in Minitab16 (Ryan, Ryan & Joiner 1972) (Figure 7.2). The total areas for mean *a priori* and participant conservation significance scores were compared to determine the distribution of polygons (Figure 7.3).

7.1.3 Results

The aesthetics conservation value was most sensitive to participant valuing, as participants gave it significantly higher scores as they did for wilderness (Table 7-1). The Aboriginal heritage conservation value was most stable with consistent maximum scoring between the *a priori* significance valuing and that of participants. In terms of mean significance scores and their distribution the greatest difference was at the lower end of the value scoring range (<50) due to the influence of higher scoring of aesthetics (Figure 7.3).

Overall, the *a priori* conservation significance scoring was stable for scores >50, where rainforest, rainforest river landscapes and wilderness were clustering spatially and had stronger positive correlation between the independent valuing and participant valuing (Figure 7.2).

7.1.4 Conclusion

Therefore it can be concluded that the *a priori* international significance valuing of Aboriginal heritage, biodiversity and rainforest river landscapes was robust, similarly, the national significance valuing of rainforest was robust. The *a priori* significance of the aesthetics values was the least stable when compared to participant significance valuing. This was not unexpected as the valuing of aesthetics is subjective, and therefore probable that its valuing would be highly variable amongst individuals.

Table 7-1 – Variation in score and distribution of conservation significance scores.

Value	***1a***	***1b***	***c***	***R^2***	***2a***	***2b***	***d***
Aboriginal heritage	**100**	**100**	*0.00*	17.50	19.61	14.75	-4.86
Biodiversity	**100**	87	-12.76	14.10	8.92	*6.00*	-2.92
Aesthetics	*12.50*	83	**70.36**	*13.00*	*3.58*	25.33	**21.75**
Rainforest river landscapes	**100**	78	-21.52	**63.50**	**43.25**	**42.75**	*-0.50*
Wilderness	25	75	49.67	76.40	4.20	18.25	14.05
Rainforest	50	*63*	13.24	62.50	25.81	31.00	5.19
Mean	64.58	81	98.98	41.17	17.56	23.01	5.45

Highest values in bold, lowest in italic, 1a = independent conservation significance score (Figure 7.1a), 1b = participant conservation significance score (Figure 7.1b), c = variation between 1a and 1b, R^2 = correlation between distribution of mean independent significance scores and participant mean significance score (Figure 7.2), 2a = total mean significance score of polygons for the independent significance valuing (Figure 7.1a), 2b = total mean significance score of polygons for the participant significance valuing (Figure 7.1b) and d = variation between 2a and 2b.

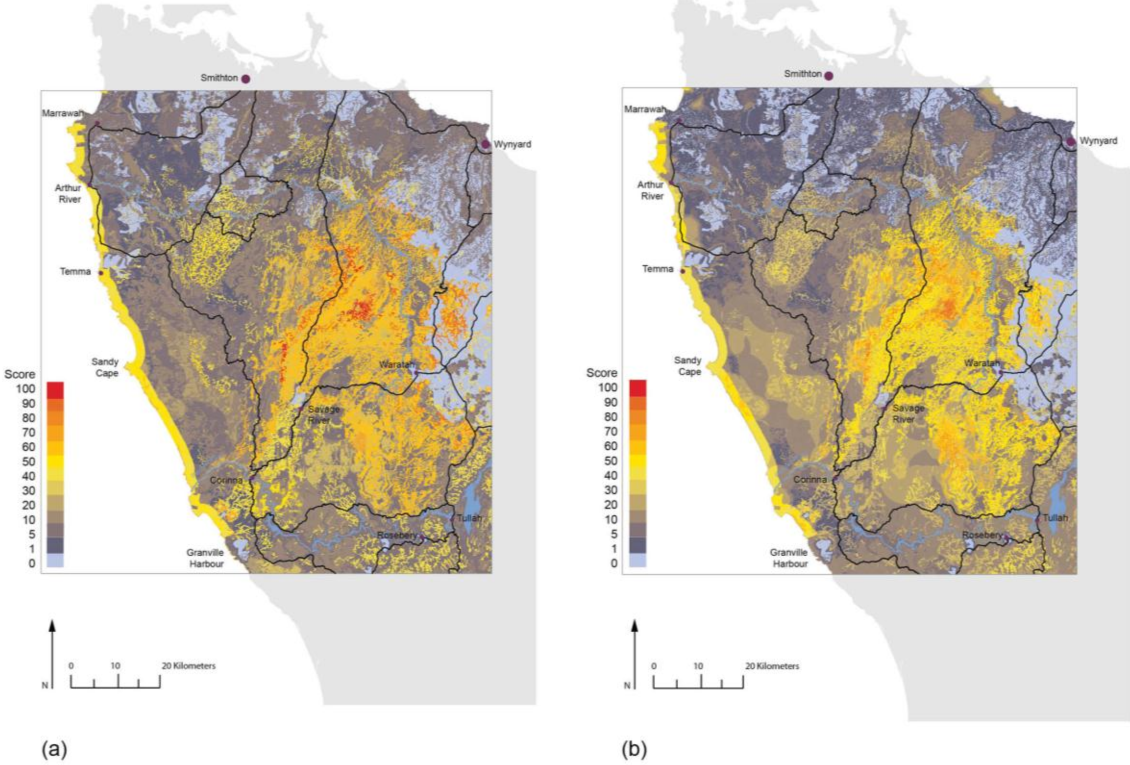

Figure 7.1 – Conservation significance sensitivity.

(a) Independent conservation significance score and (b) participant conservation significance score.

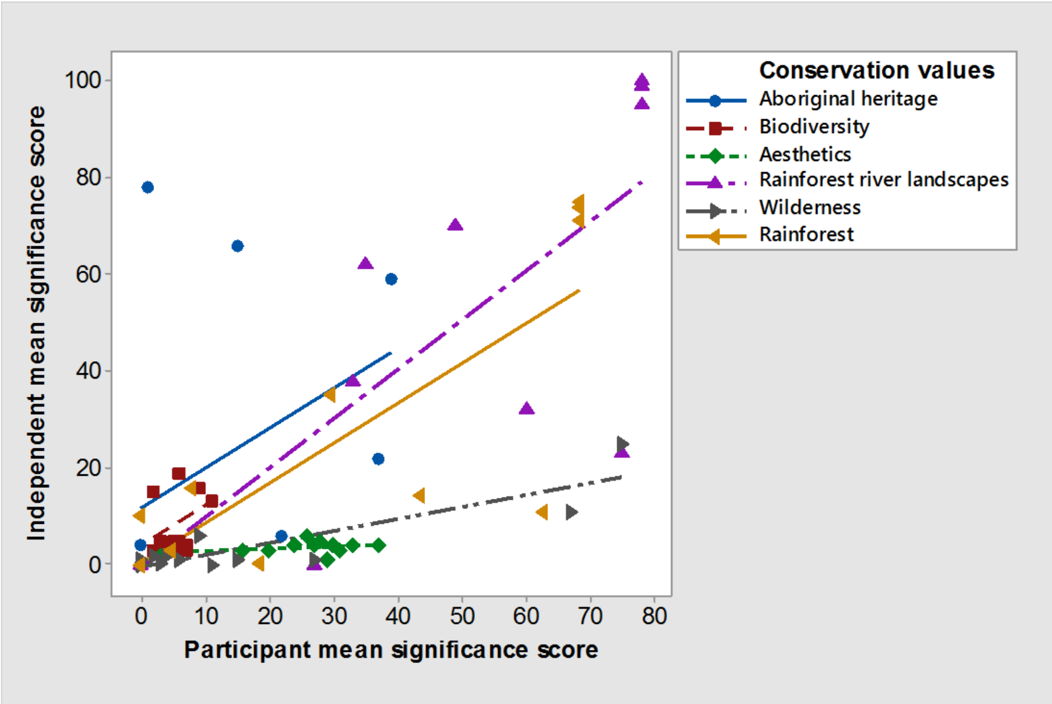

Figure 7.2 – Conservation value mean significance score distribution comparison.

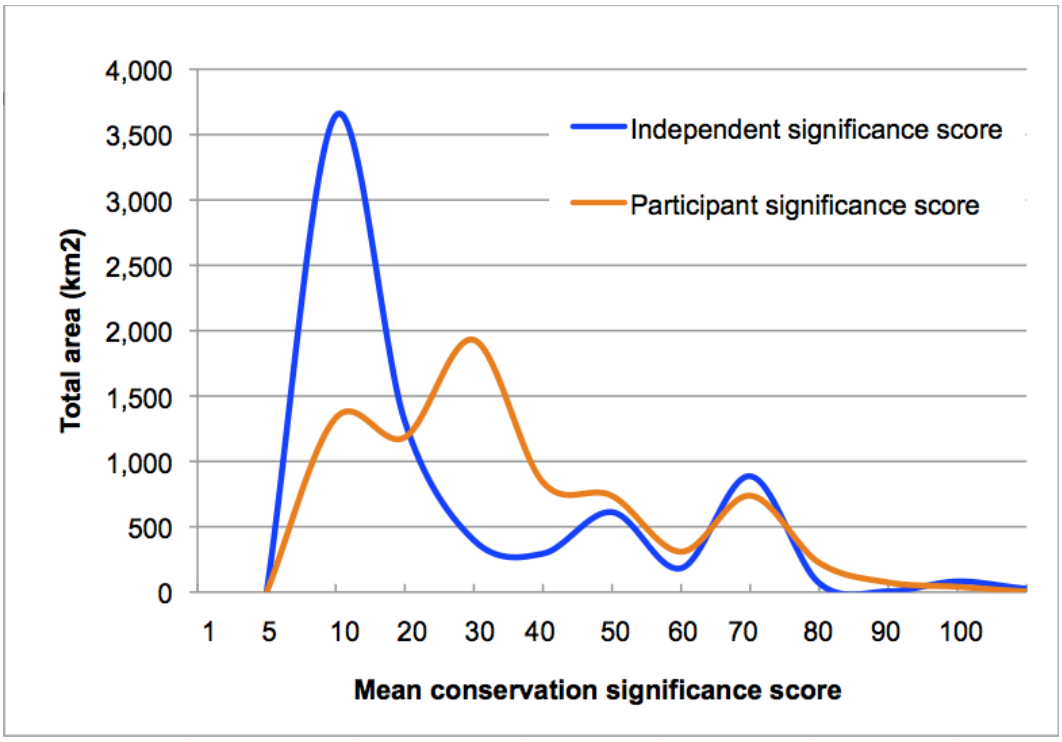

Figure 7.3 – Polygon distribution comparison of mean conservation significance scores.

7.2 Survey instrument

7.2.1 Pre-discussion personal survey

Tarkine workshop participant survey – SECTION A

HOW TO COMPLETE THIS SURVEY – Where questions require a 'Yes' or 'No' answer, or multiple response, please put a '✓' in the box beside the appropriate response.

Where a scale question is provided (e.g. Question 1) please circle the response that best applies.

1. How would you rate the level of your **general knowledge** about the Tarkine?
(Please circle just one response that best reflects your level of knowledge)

Not at all knowledgeable	Slightly knowledgeable	Somewhat knowledgeable	Moderately knowledgeable	Considerably knowledgeable	Very knowledgeable	Exceptionally knowledgeable
1	2	3	4	5	6	7

2. Have you visited the Tarkine? ☐ Yes ☐ No *(if **NO**, go to question 5)*

3. If **Yes**:

a) When was the last time (approx.)? ....
....
....

b) Where did you go last time? ....
....
....
....

c) In a year, how often would you visit? ....
....
....
....

d) What was / is the main reason for your visit? ....
....
....
....

1

4. If you have **favourite places** in the Tarkine:

a) Please list your most favourite places.

(You may also wish to mark them on the attached map on the next page)

....
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b) Why are these your favourite places?

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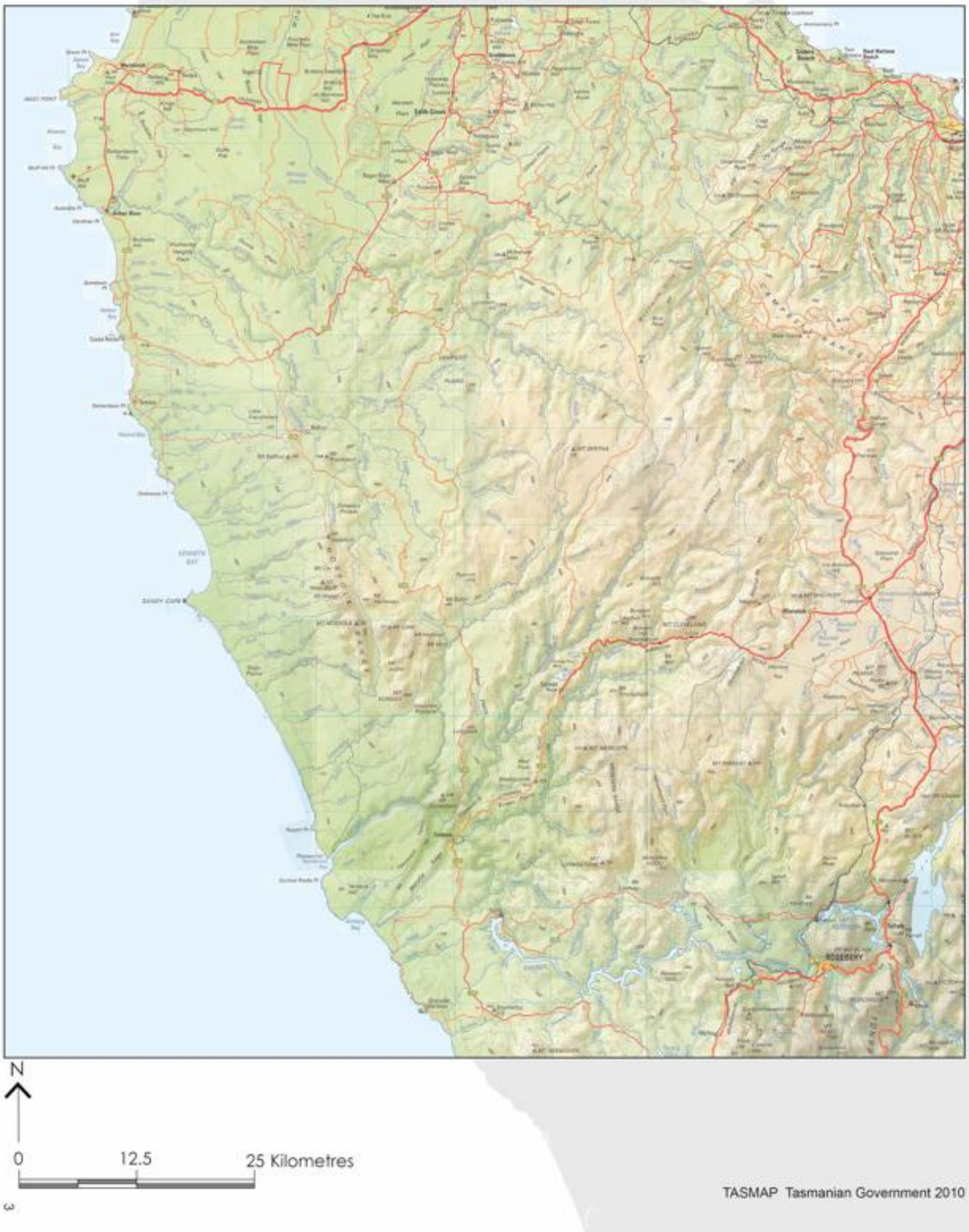
2

Please mark your **most favourite** places in the Tarkine



3

For each of the following questions, please circle the number that best reflects your opinion:

Not important	Slightly important	Somewhat important	Moderately important	Considerably important	Very important	Extremely important
1	2	3	4	5	6	7

5. **For you personally,** how **important** is the Tarkine for the following benefits?

	Not important 1	2	3	4	5	6	**Extremely important** 7
a) Providing a place to go off road 4 wheel driving, quad and motor bike riding	1	2	3	4	5	6	7
b) Providing a place to go hiking and walking	1	2	3	4	5	6	7
c) Providing a place to be with/ share with family/ friends	1	2	3	4	5	6	7
d) Providing a place to go fishing	1	2	3	4	5	6	7
e) Providing direct commercial/ economic/ employment opportunities for me personally	1	2	3	4	5	6	7
f) Providing a place to rest/ relax, take time out, contemplate	1	2	3	4	5	6	7
g) Providing a place to connect with European heritage	1	2	3	4	5	6	7
h) Providing a place to go camping	1	2	3	4	5	6	7
i) Providing a place to explore	1	2	3	4	5	6	7
j) Providing a place to connect with Aboriginal cultural heritage	1	2	3	4	5	6	7
k) Providing a place for hunting	1	2	3	4	5	6	7
l) It is good to know it is there for nature	1	2	3	4	5	6	7
m) Providing a place to drink and party away from others	1	2	3	4	5	6	7
n) Other *(Please specify in the box below)*	1	2	3	4	5	6	7

6. **For the Tasmanian community as a whole,** how **important** is the Tarkine for the following?

	Not important 1	2	3	4	5	6	Extremely important 7
a) Providing habitat for plants and animals	1	2	3	4	5	6	7
b) Aboriginal cultural heritage	1	2	3	4	5	6	7
c) Providing economic benefits	1	2	3	4	5	6	7
d) Recreation (fishing, surfing, canoeing, hiking)	1	2	3	4	5	6	7
e) Scenic landscape	1	2	3	4	5	6	7
f) Providing employment opportunities	1	2	3	4	5	6	7
g) Providing clean water and air	1	2	3	4	5	6	7
h) Enhancing environmental awareness and knowledge	1	2	3	4	5	6	7
i) Wilderness	1	2	3	4	5	6	7
j) Off road 4 wheel driving, quad and motor bike riding	1	2	3	4	5	6	7
k) Providing carbon storage in its forests	1	2	3	4	5	6	7
l) Other *(Please specify in the box below)*	1	2	3	4	5	6	7

7. Are you a member of a club or organisation that has an interest in the Tarkine?

☐ Yes ☐ No

If yes, please specify……………………………………………………………………………………

8. Are you employed by a business that has an interest in the Tarkine?

☐ Yes ☐ No

If yes, what sector?………………………………………………………………………………………

5

For each of the following questions, please circle the number that best reflects your opinion:

Not at all	To a little extent	To a slight extent	To a moderate extent	To a considerable extent	To a significant extent	To an extreme extent
1	2	3	4	5	6	7

9. **For you personally**, to what extent to do you identify yourself as:

	Not at all						Extreme extent
a) A conservationist	1	2	3	4	5	6	7
b) A person in favour of economic development	1	2	3	4	5	6	7
c) A person who enjoys nature	1	2	3	4	5	6	7
d) A person in favour of a balance between conservation and development	1	2	3	4	5	6	7
e) An activist	1	2	3	4	5	6	7
f) A person who is a traditional recreationist (enjoys 4 wheel driving, fishing and hunting)	1	2	3	4	5	6	7
g) A lobbyist	1	2	3	4	5	6	7
h) Other *(Please specify in the box below)*	1	2	3	4	5	6	7

10. In terms of **community involvement:**

	Not at all						Extreme extent
a) Have you been or are you involved in any **discussion forums** or **consultation processes** related to the Tarkine? *(Please specify in the box below)*	1	2	3	4	5	6	7

6

11. Do you identify yourself as Tasmanian Aboriginal? ☐ Yes ☐ No

12. What is your gender? ☐ Male ☐ Female ☐ Other

13. How old are you?

☐ 18-29 years ☐ 30-44 years ☐ 45-59 years ☐ over 60 years

14. What is the highest level of formal education you have completed so far?

☐ Primary ☐ Secondary ☐ Tertiary A (Technical college) ☐ Tertiary B (University)

15. What is the postcode of the place where you currently live? ……………………Postcode

Please add any additional comments below.

Additional Comments

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7

7.2.2 Post-discussion personal survey

Tarkine workshop participant survey – SECTION B

HOW TO COMPLETE THIS SURVEY – Where questions require a 'Yes' or 'No' answer, or multiple response, please put a '✓' in the box beside the appropriate response.

Where a scale question is provided (e.g. Question 19) please circle the response that best applies.

16. Which map series did **you** choose to look at?

☐ Conservation ☐ Development

17. Did **you** choose a development or conservation map option that reflected your view?

☐ Yes ☐ No

18. If **Yes**, which one?

☐ A ☐ B ☐ C ☐ D ☐ E ☐ F

☐ G ☐ H ☐ I ☐ J ☐ K

For each of the following questions, please circle the number that best reflects your opinion:

Not changed	Slightly changed	Somewhat changed	Moderately changed	Considerably changed	Strongly changed	Extremely changed
1	2	3	4	5	6	7

19. **<u>To what extent</u>** have you changed your thinking about the Tarkine now that you have seen the mapping options?

	Not changed 1	2	3	4	5	6	**Extremely changed** 7
a) How much development could take place	1	2	3	4	5	6	7

Please specify...
....

b) How much could be conserved	1	2	3	4	5	6	7

Please specify...
....

8

	Not changed 1	2	3	4	5	6	Extremely changed 7
c) Thoughts about conflict	1	2	3	4	5	6	7

Please specify……………………………………………………………………………………
……………………………………………………………………………………………………

d) What values you **would** compromise	1	2	3	4	5	6	7

Please specify……………………………………………………………………………………
……………………………………………………………………………………………………

e) What values you **wouldn't** compromise	1	2	3	4	5	6	7

Please specify……………………………………………………………………………………
……………………………………………………………………………………………………

f) Your awareness of the range of values in the Tarkine	1	2	3	4	5	6	7

Please specify……………………………………………………………………………………
……………………………………………………………………………………………………

g) Other	1	2	3	4	5	6	7

Please specify……………………………………………………………………………………
……………………………………………………………………………………………………

For each of the following questions, please circle the number that best reflects your opinion:

Not useful	Slightly useful	Somewhat useful	Moderately useful	Considerably useful	Very useful	Extremely useful
1	2	3	4	5	6	7

---

20. **<u>For you personally</u>,** how **useful** has this mapping process been?

	Not useful 1	2	3	4	5	6	Extremely useful 7
a) Understanding the economic values of the Tarkine	1	2	3	4	5	6	7

Please specify……………………………………………………………………………………
……………………………………………………………………………………………………

9

	Not useful 1	2	3	4	5	6	Extremely useful 7
b) Understanding the natural values of the Tarkine	1	2	3	4	5	6	7

Please specify..
....

c) Understanding the importance of the Tarkine	1	2	3	4	5	6	7

Please specify..
....

d) Understanding what values you **would** compromise	1	2	3	4	5	6	7

Please specify..
....

e) Understanding what values you **wouldn't** compromise	1	2	3	4	5	6	7

Please specify..
....

f) Other	1	2	3	4	5	6	7

Please specify..
....

21. Are there important areas for **conservation** that you would **not compromise**?
☐ Yes ☐ No

22. If you answered **Yes**, can you please draw them on the attached map on the last page?

23. Are there important areas for **development** that you would **not compromise**?
☐ Yes ☐ No

24. If you answered **Yes**, can you please draw them on the attached map on the last page?

25. What information was missing that would have helped you make a decision about the possible conservation or development of the Tarkine?

Please specify..
....
....

10

Thankyou for your participation

Please add any additional comments below.

Additional Comments

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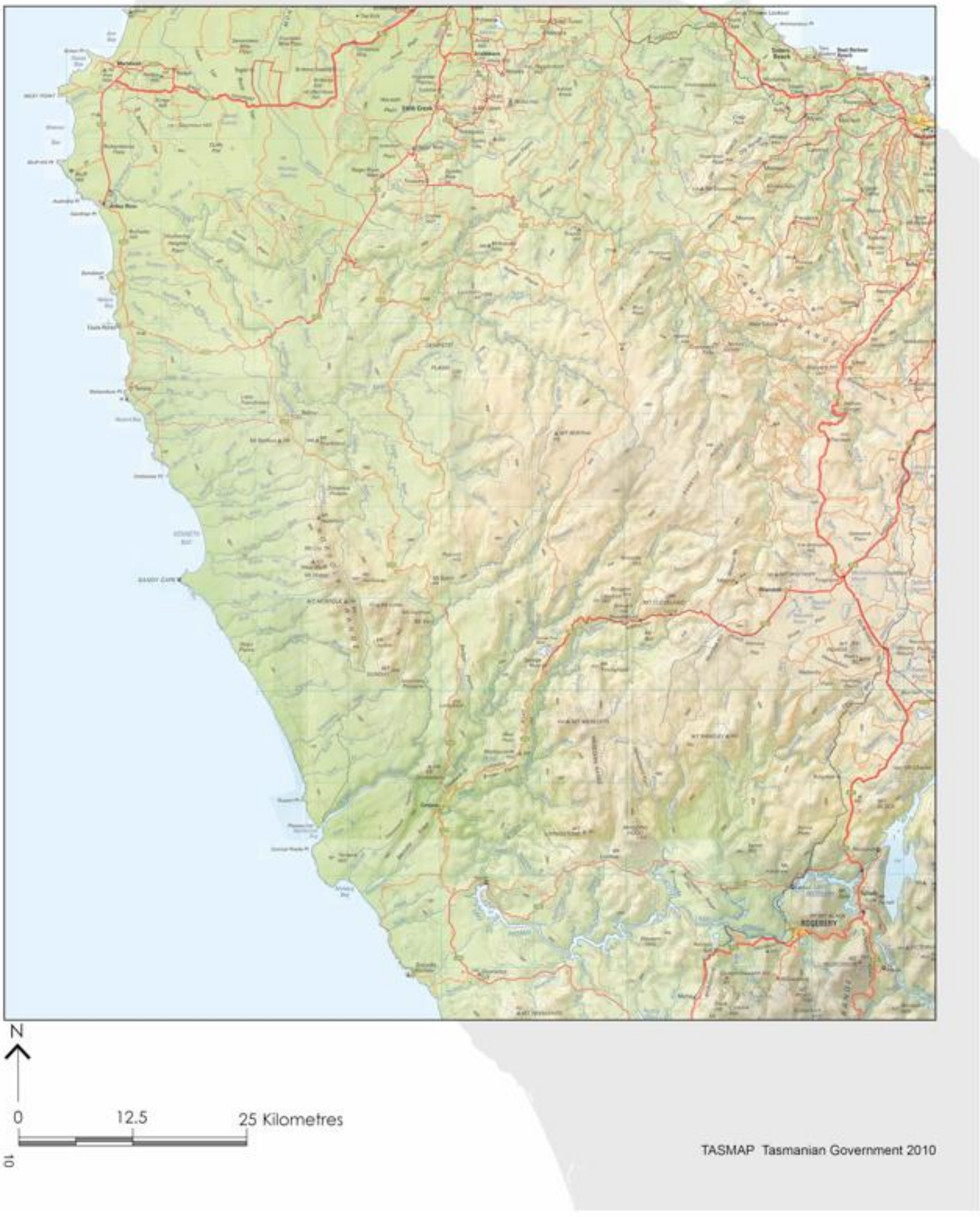
11

Please mark important areas you **would not** compromise



12

7.2.3 Workshop group discussion survey

Tarkine workshop discussions – SECTION A

Please describe your group discussions in the empty boxes.

Question	Discussions
1. In relation to the Tarkine, what do you consider the **3 most important** issues to you personally? *(some examples might be:)* · conservation management · economic development · recreation opportunities · employment opportunities · Aboriginal cultural heritage · wilderness protection · plant and animal habitat · scenic landscape · biodiversity · education and knowledge · others?	*Please place your issues here (use sticky notes for your **individual** top 3 issues)*

1

Question	Discussions *(Please note your group discussions)*
2. **Why** are these issues important to you?	
3. Do you have a view on development or conservation or of the Tarkine? Would you like to see more conservation or more development, or no change or other options?	

Question	**Discussions** (*Please note your group discussions)*
4. **Why** do you have this view about conservation or development?	
5. What do you see as the **conflicts** about the Tarkine?	

3

Question	**Discussions** (*Please note your group discussions)*
6. What economic or conservation values would you **not comprise**? Why?	
7. What conservation or economic values **would you comprise**? Why?	

4

Tarkine workshop discussions – SECTION B

Please wait until you are prompted to proceed onto this part of the workshop discussions.

Question	**Discussions** (*Please note your group discussions)*
8. Is there a map option that you prefer? **Why**? *(Please list the map option from A to K that you would prefer)*	
9. What is your acceptable level of development or conservation? **Why**?	

5

Question	**Discussions** (*Please note your group discussions)*
10. Are the values that have been mapped **important** to you?	
11. Has there been enough or the right sort of **information** provided to help you make a decision about development or conservation? What sort of additional information would have helped you make a decision?	

6

Question	**Discussions** (*Please note your group discussions)*
12. What do you think now about development or conservation now that you have seen the options? **Why**?	
13. Have you changed your thinking about development / conservation? **Why**?	

7

Question	**Discussions** (*Please note your group discussions)*
14. What are your thoughts now about **conflict** in the Tarkine?	
15. Have you **changed** your thinking about what values you would or wouldn't compromise?	

8

Question	**Discussions** (*Please note your group discussions)*
16. Have you **increased** your awareness of the range of values in the Tarkine?	
17. Has this process been useful / interesting to you? **Why**?	

9

7.2.4 Workshop mapping materials

7.2.4.1 Conservation values maps

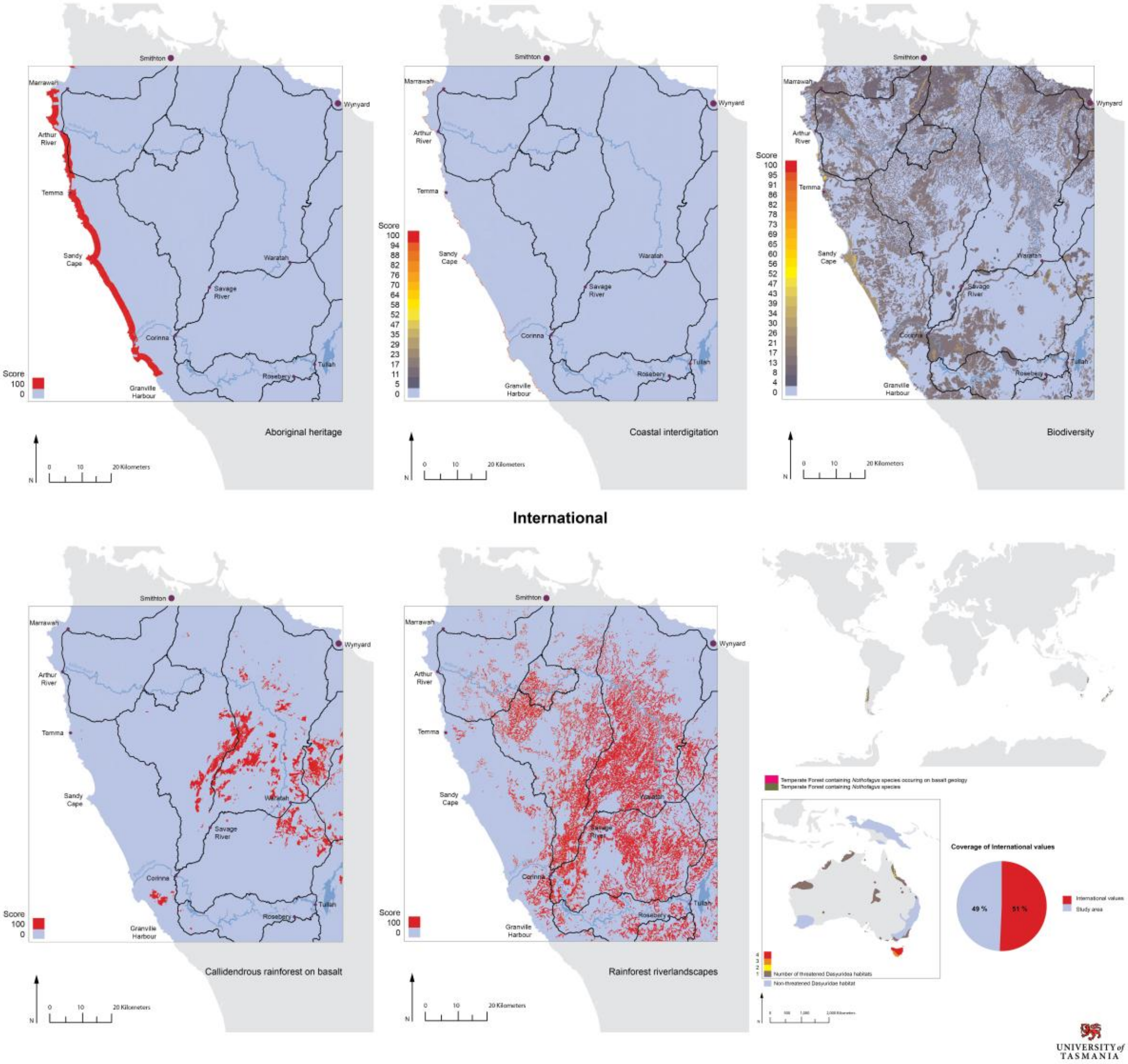


Figure 7.4 – Internationally significant conservation values.

7.2.4.2 Conservation values maps cont.

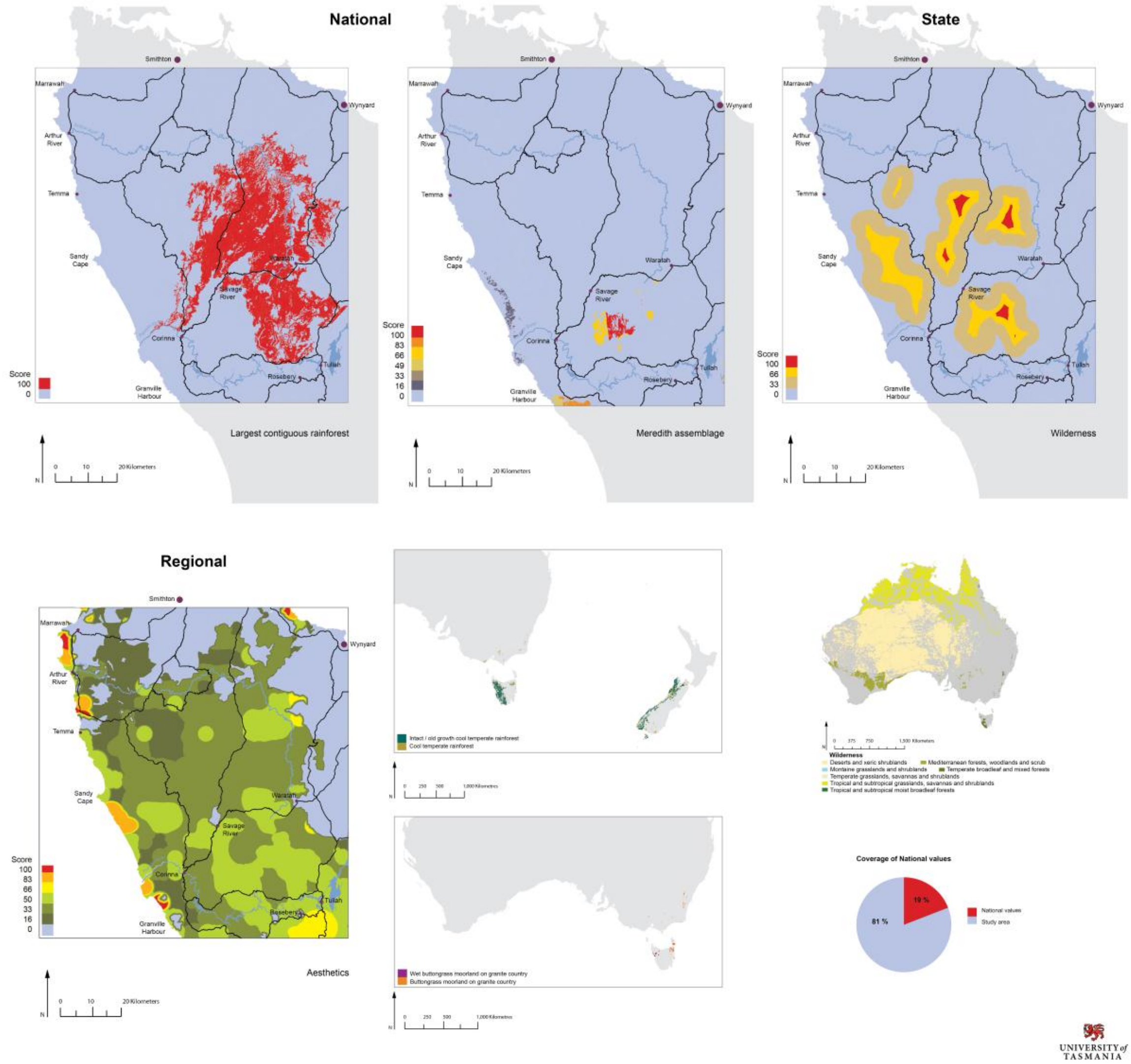


Figure 7.5 – Conservation values of national, State and regional significance.

7.2.4.3 Development values maps

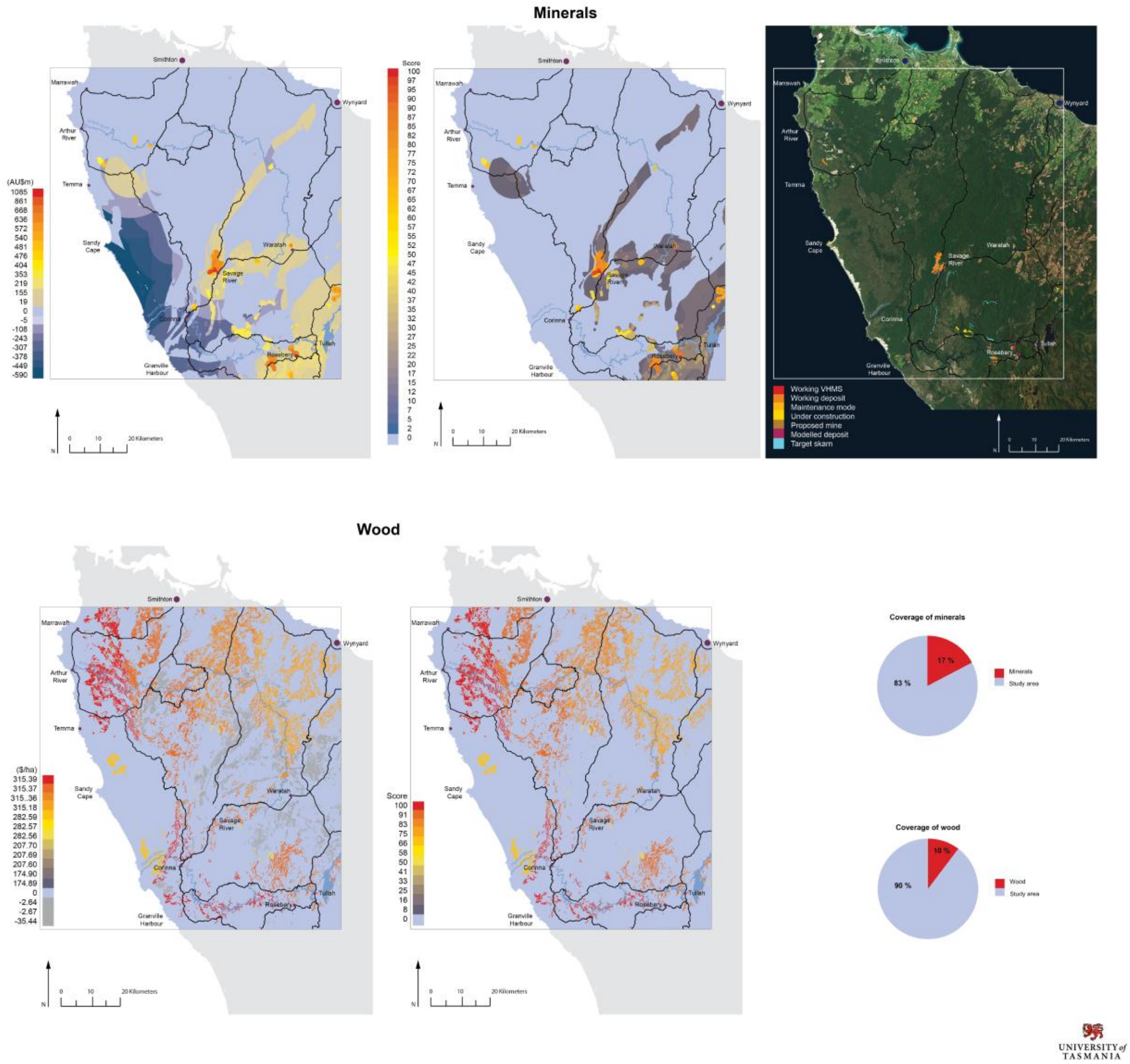


Figure 7.6 – Development values.

7.2.4.4 Significance scoring system

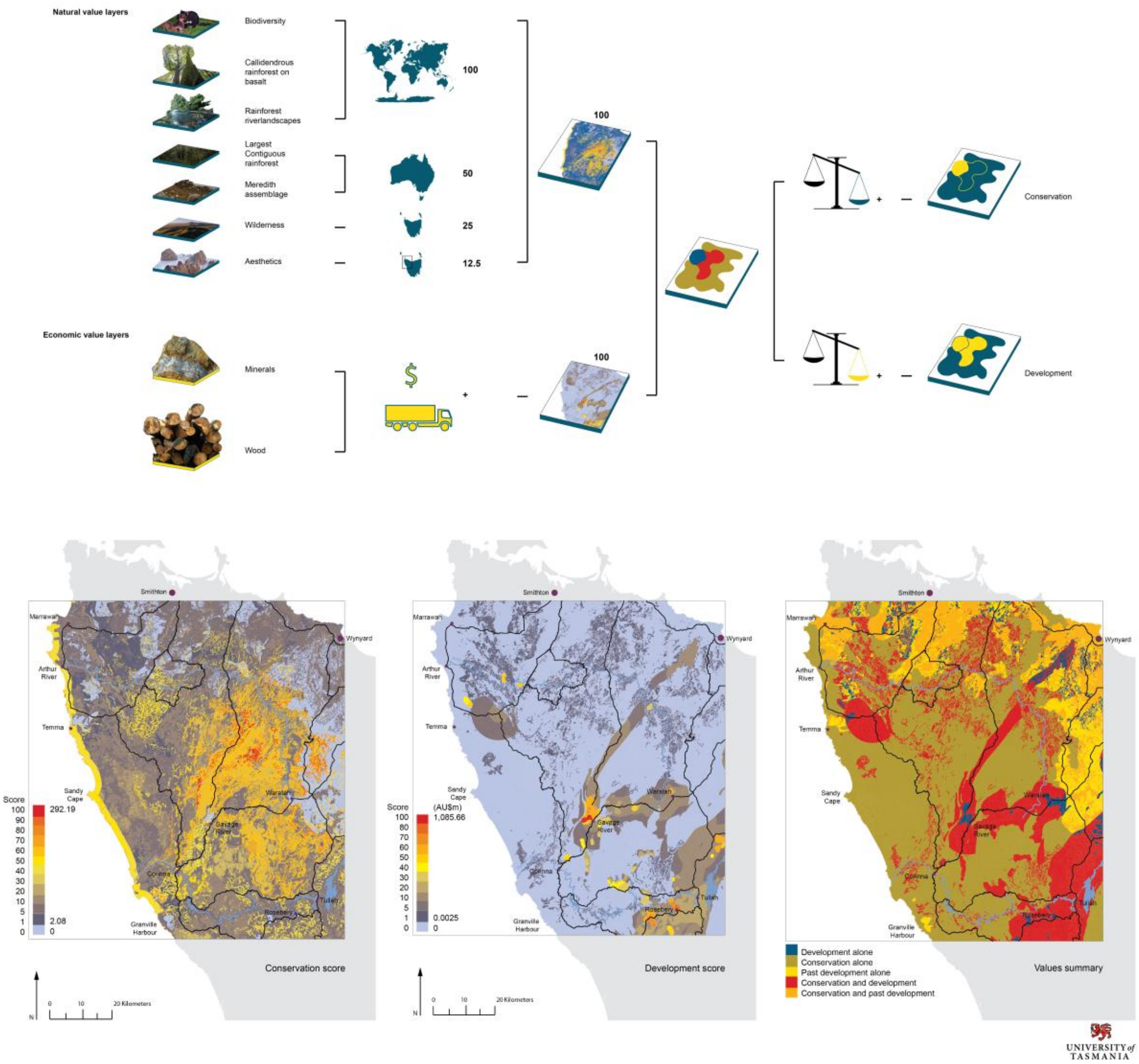


Figure 7.7 – Significance scoring system.

7.2.4.5 Conservation biased map choice sequence

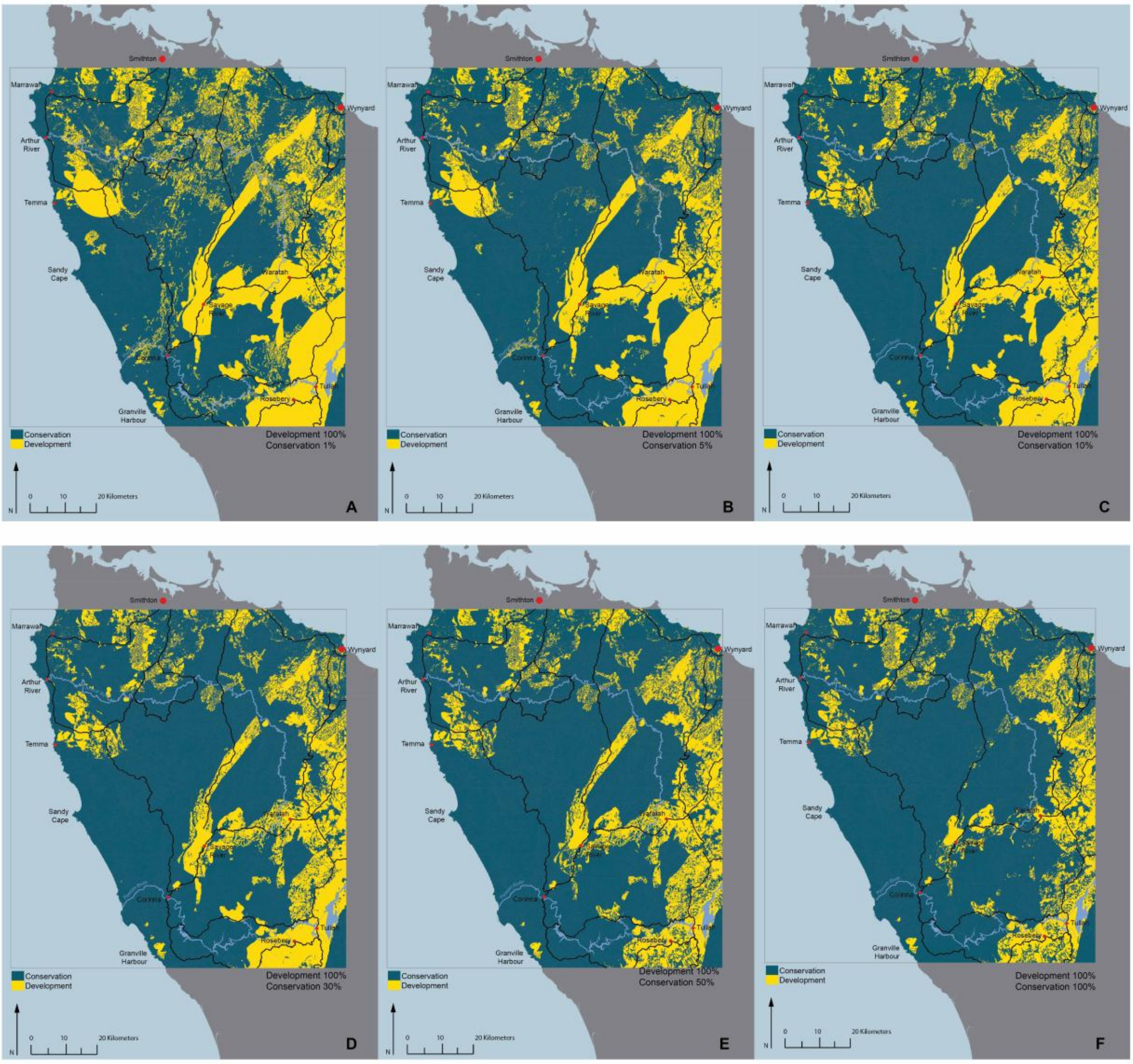


Figure 7.8 – Conservation biased map choice sequence.

7.2.4.6 Conservation biased map choice sequence cont.

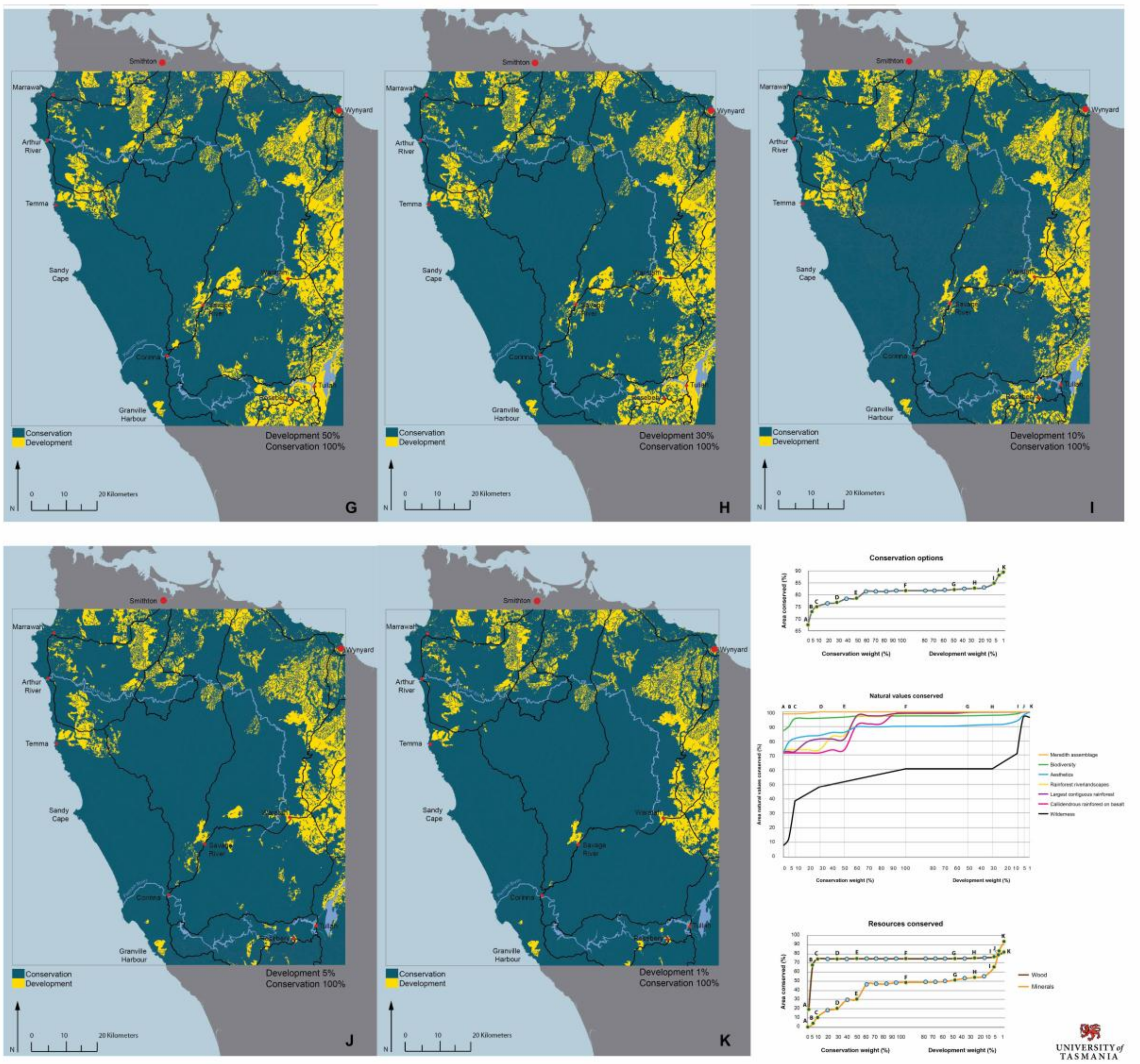


Figure 7.9 – Conservation biased map choice sequence cont.

7.2.4.7 Development biased map choice sequence

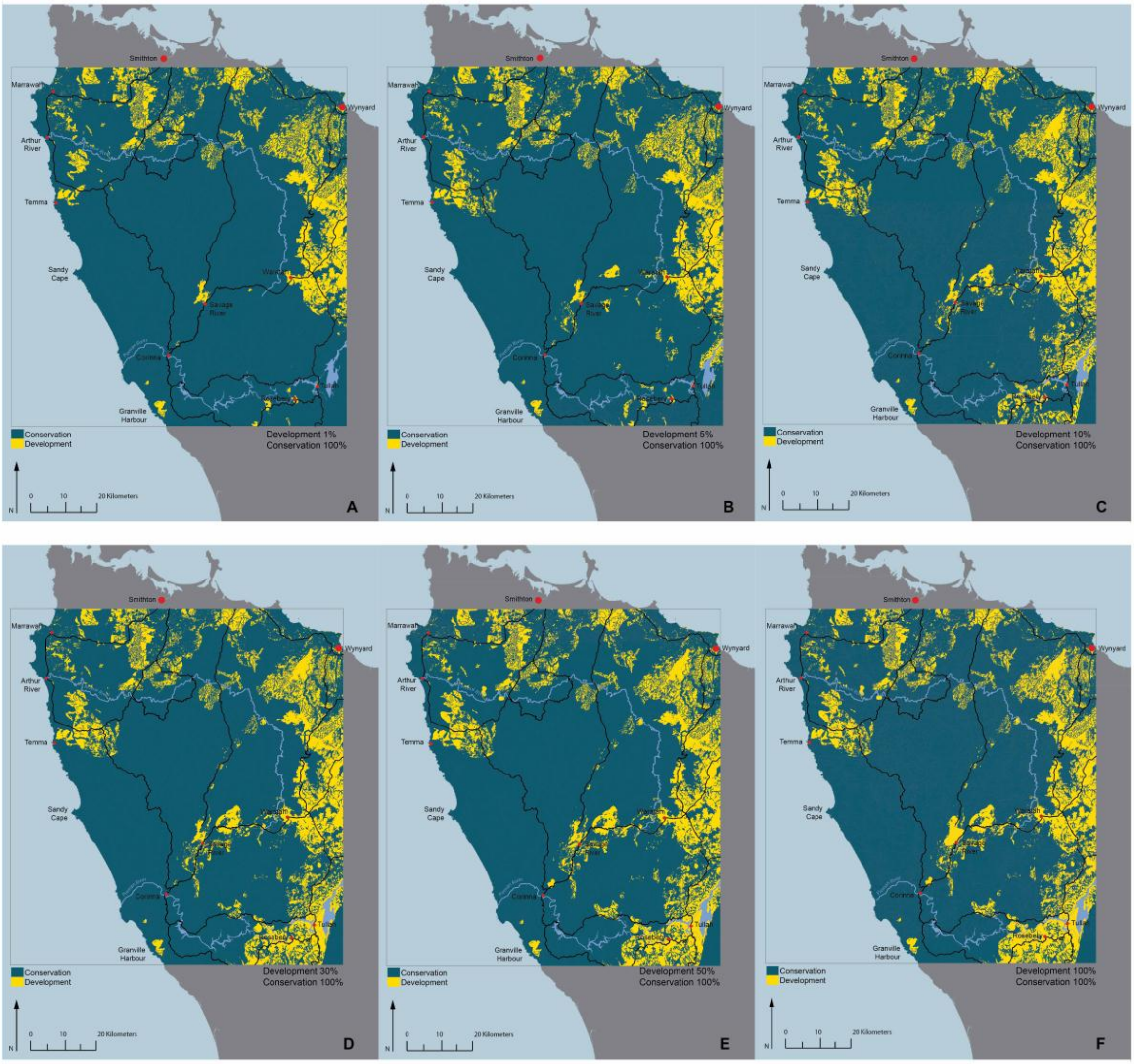


Figure 7.10 – Development biased map choice sequence.

7.2.4.8 Development biased map choice sequence cont.

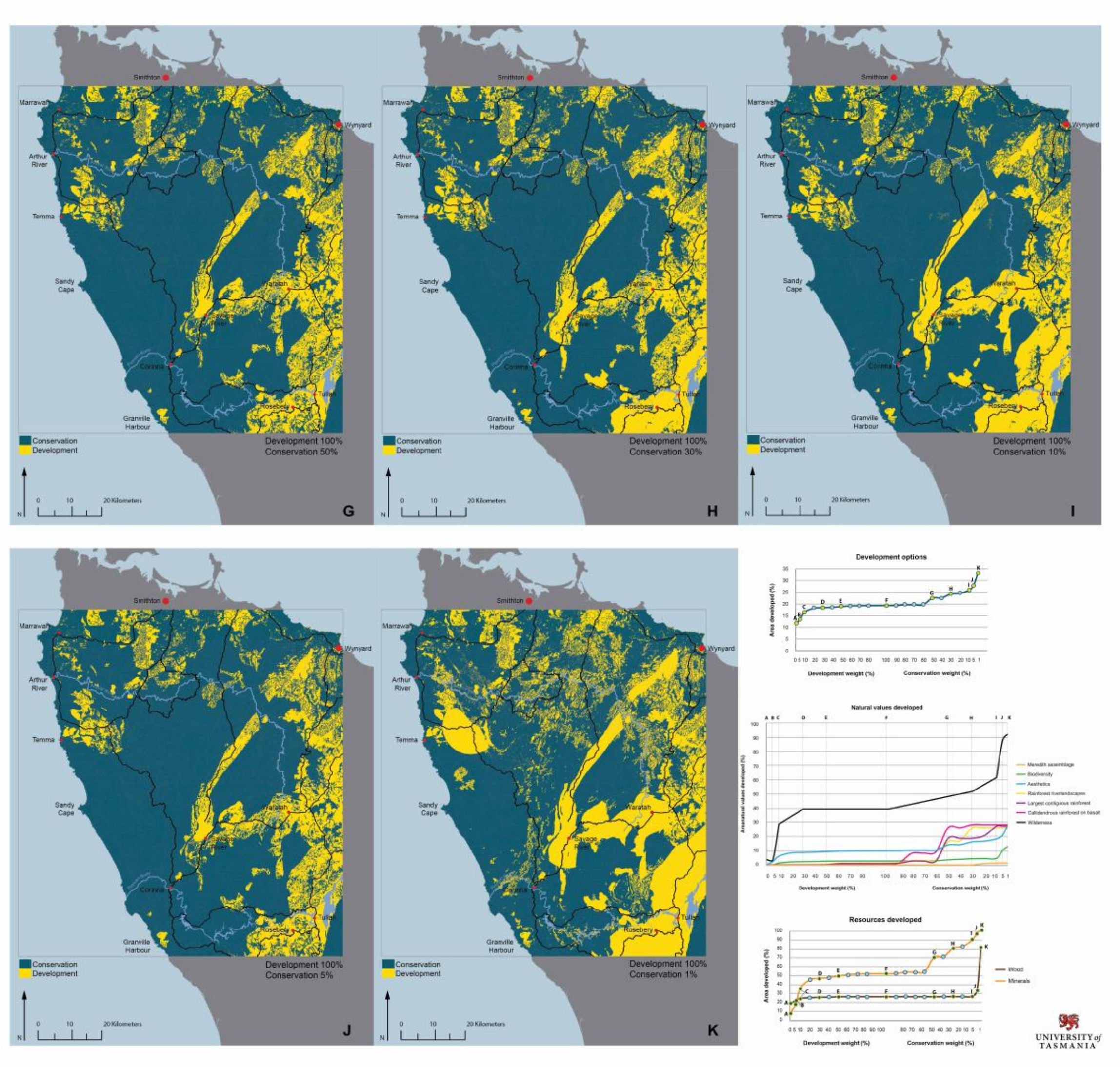
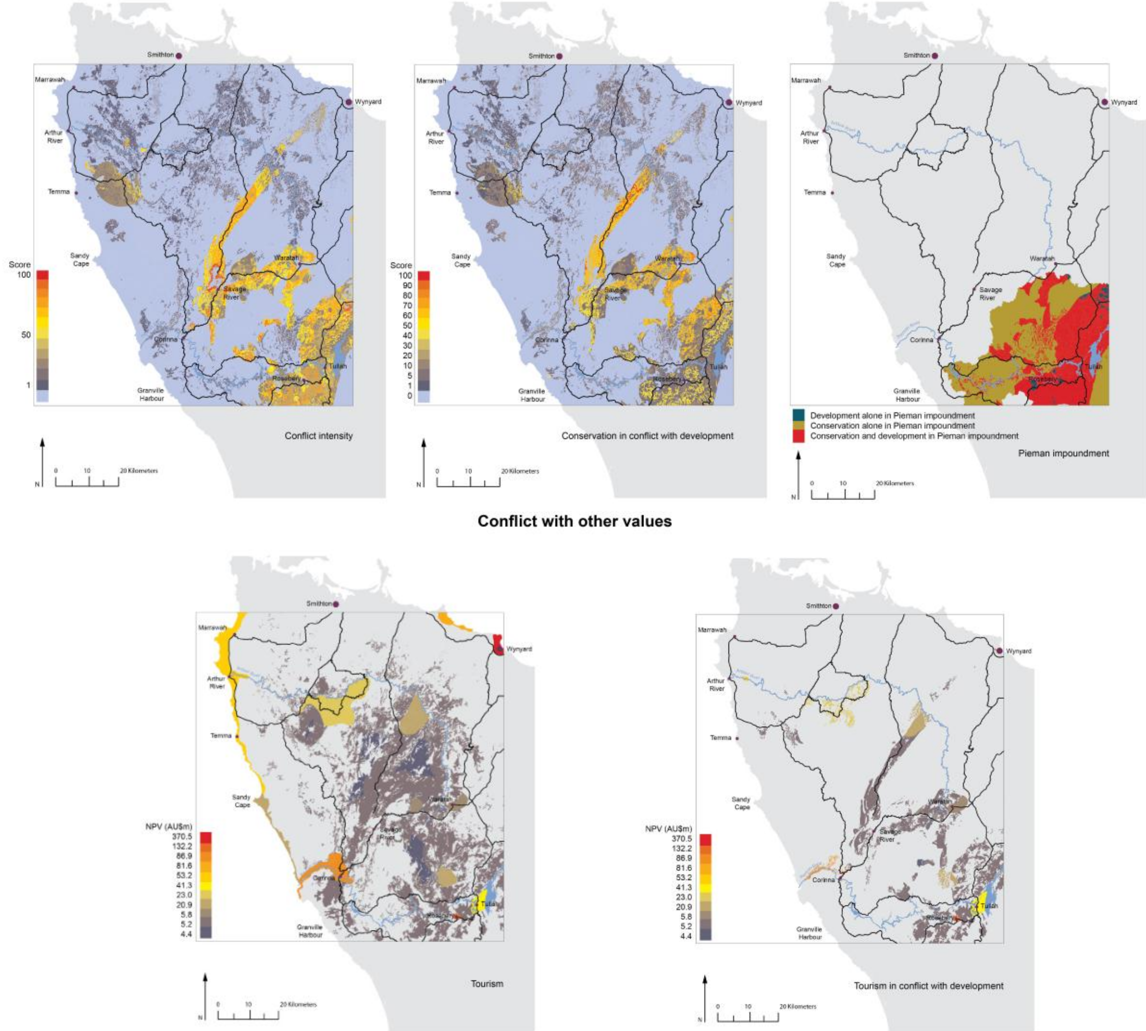


Figure 7.11 – Development biased map choice sequence cont.

7.2.4.9 Values conflict maps



UNIVERSITY of TASMANIA

Figure 7.12 – Values conflict maps.

7.2.4.10 Values conflict maps cont.

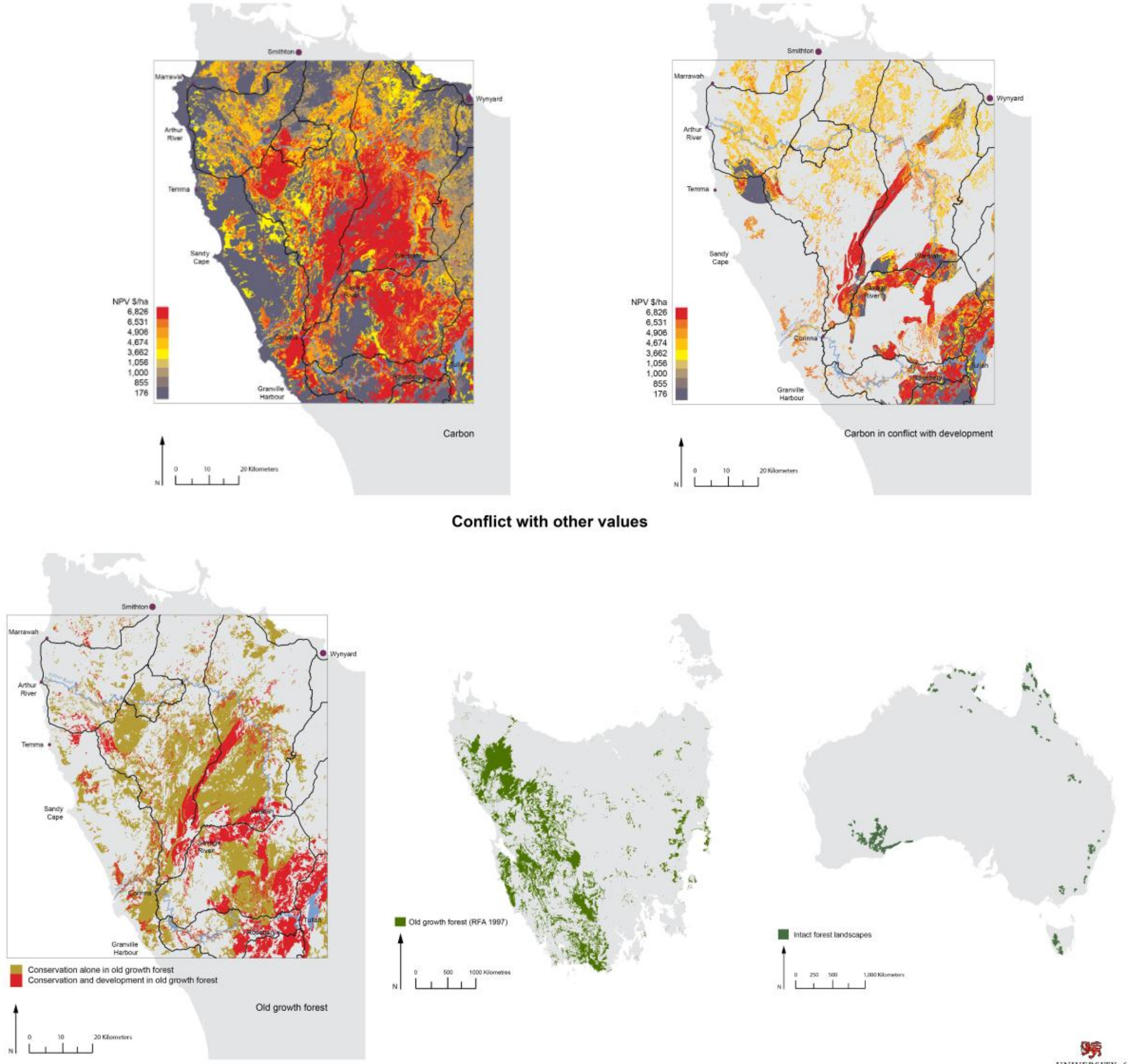


Figure 7.13 – Values conflict maps cont.

7.2.4.11 Workshop process

Workshop welcome:

Welcome, provide copy of study background document and explain study.

Provide consent form and confirm consent.

Explain the workshop process:

Going to break into to groups (say 3 or 4 people in each group) to work together and share ideas / views about the Tarkine.

Each group to have A3 sheets with discussion topics and space to note their thoughts.

All comments are accepted.

Not a consensus exercise; want them to note all their ideas in blank spaces provided on sheet. Choose someone to scribe.

At the start of the workshop, there will be a short survey to fill in seeking information on how well they know the Tarkine and what their personal interests are. At the end it will be revisited and finished to see if their views have changed.

Personal survey:

Each participant asked to fill out short 1 page questionnaire, (section A, questions 1 to 19)

Start group conversations: Section A (questions 1 to 7)

Provide each group with A3 discussion sheets.

For question 1, people use sticky notes to put their personal top 3 issues, then collate and discuss as a group.

Introduce the layers:

Provide each group with copies of the maps for natural and economic layers.

Explain the layers using projector screen so that they can choose to follow on maps or look at screen.

Ask if is there are questions.

Explain the scoring system:

Provide each group with copies of the scoring system map.

Explain how the layers are scored.

Explain how they are combined.

Explain the weighting.

Ask if there are questions.

Explain conservation / development options:

Provide each group with copies of the **development and conservation maps**.

Take them through the map series (A to K) and explain the graphs.

Ask if there are questions.

Continue the group conversations: Section B (questions 8 to 17)

What do you think of the scenarios?

Is there one that you prefer? Why?

What is your acceptable level of development / conservation? Why? What isn't an acceptable level of development / conservation? Why? Are the values that have been mapped important to you? Is all the information here that you need to make a decision?
Revisit their previous stance from the start: What do you think now about development / conservation now that you have seen the options? Why? Have you changed your thinking about development / conservation? Why? What information was missing that would have helped you make a decision? Why? What are your thoughts now about conflict in the Tarkine? Have you changed your thinking about what values you would or wouldn't compromise? Have you increased your awareness of the range of values in the Tarkine? Has this process been useful / interesting to you? Why?
Round up discussion: Bring everyone together and open the group up to their thoughts, comments and experience of the process. What did they get out of it? Was it worthwhile? What could be improved? Wrap up and thanks.
Personal survey: (section A, questions 20 to 25) Each participant asked to fill last section of survey to review his or her initial thoughts.

7.3 Miscellaneous maps

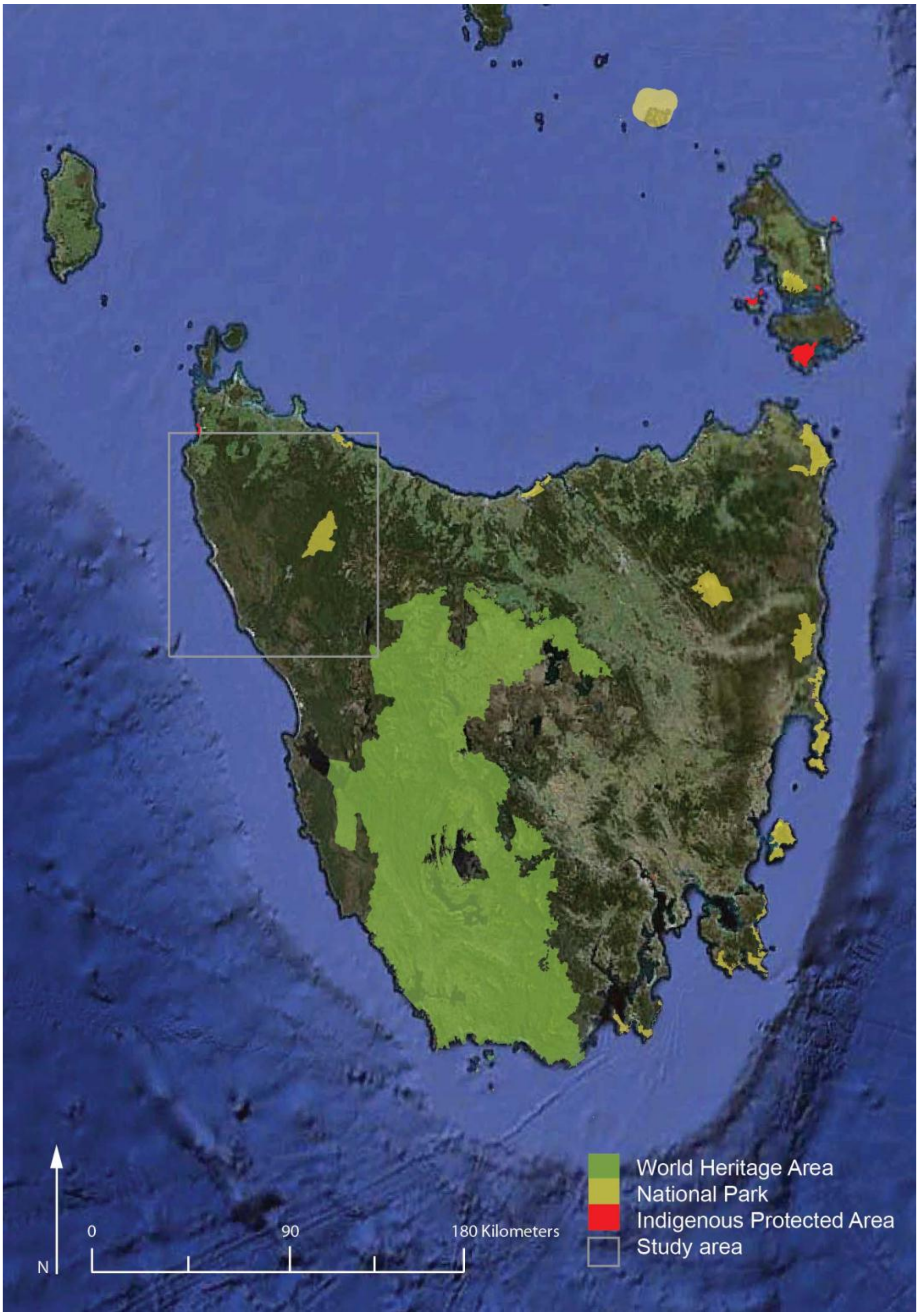


Figure 7.14 – World Heritage areas, National Parks and Indigenous Protected Areas in Tasmania.

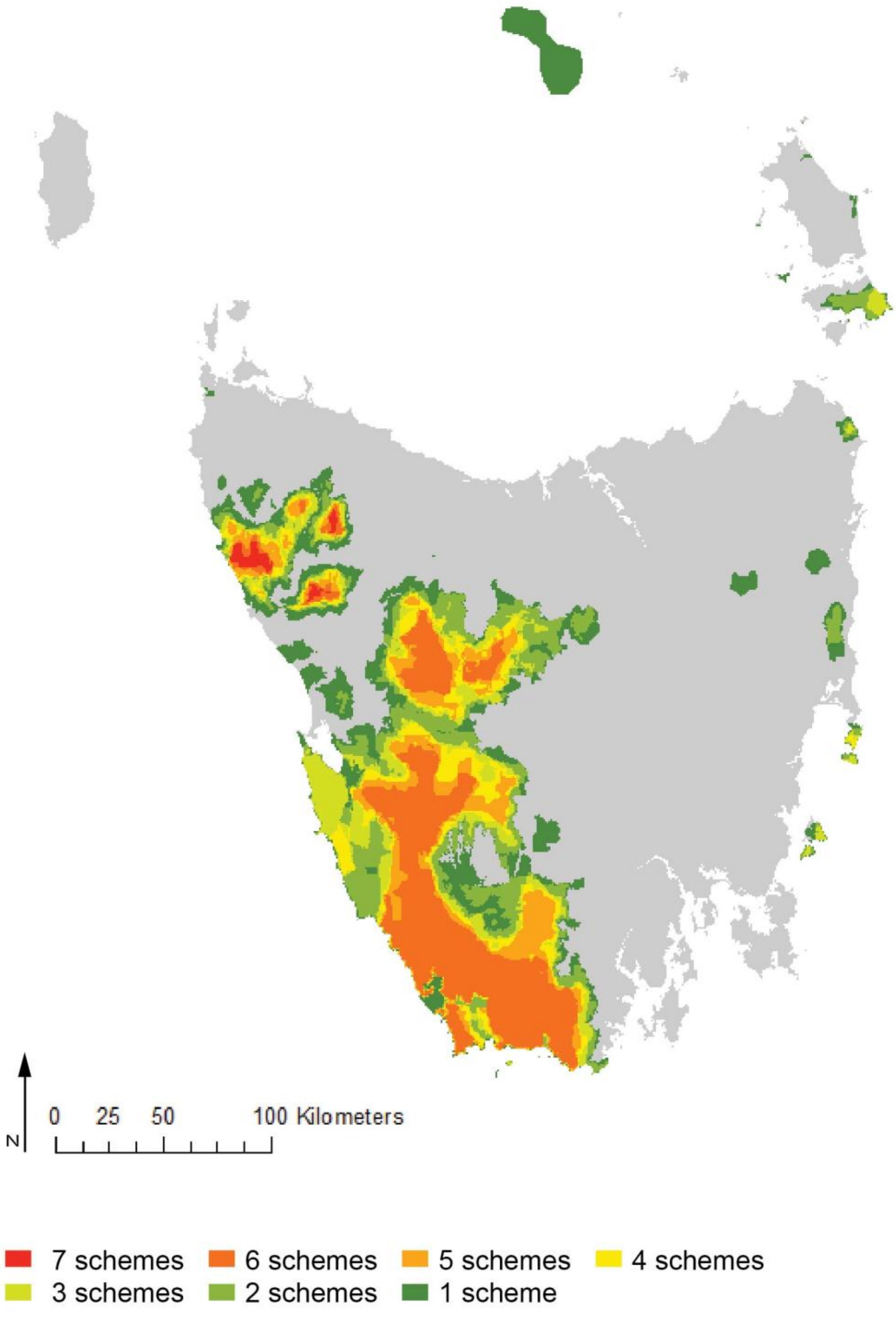


Figure 7.15 – Wilderness area mapping in Tasmania.

Areas where wilderness mapping schemes overlap in Tasmania using Russell, Mathews & Jones (1979); Kirkpatrick & Haney (1980); Harries & Brown (1992); Lesslie & Maslen (1995); RNE (1997); Mendel (2002); North & Barker (2010).

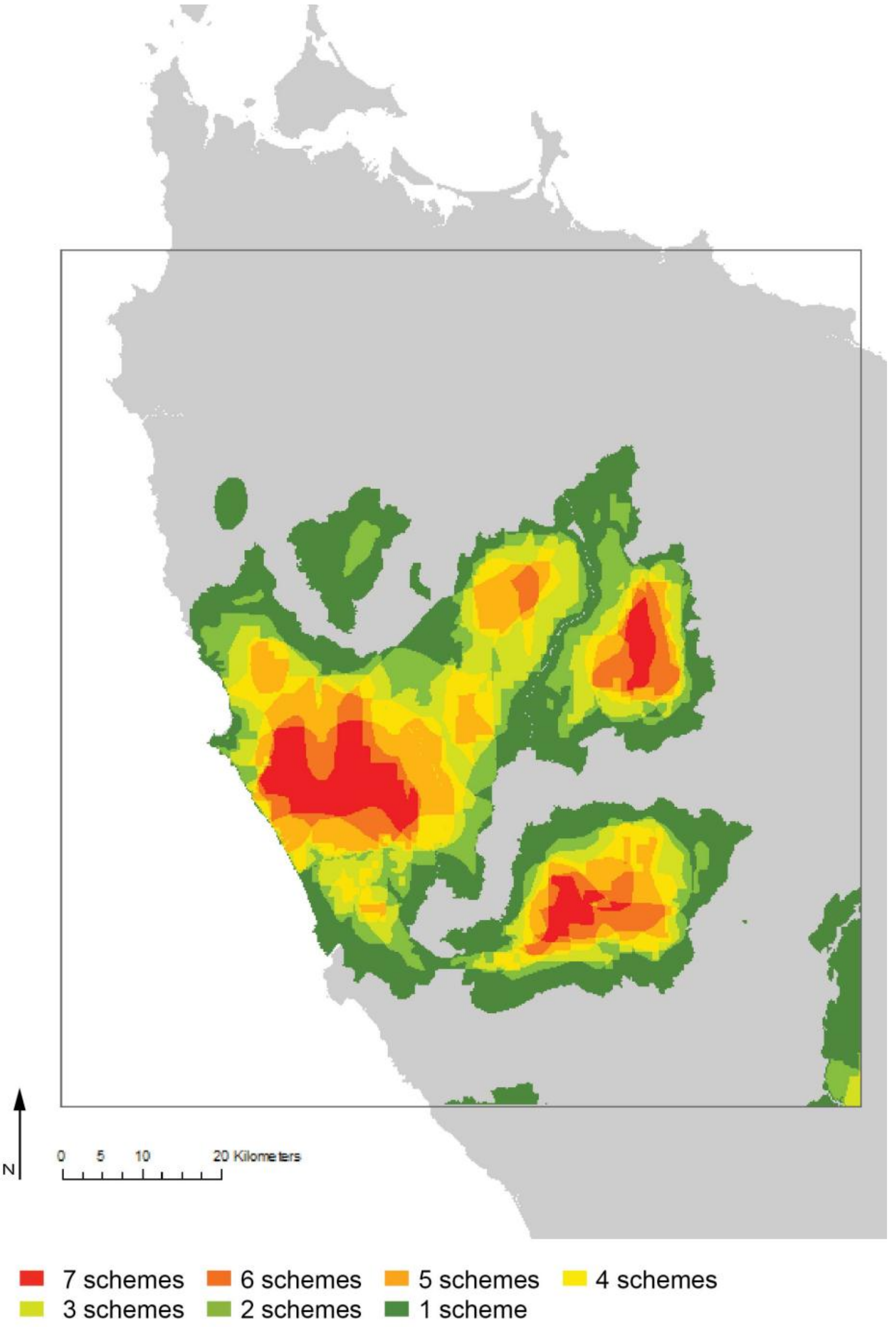


Figure 7.16 – Wilderness area mapping in the Tarkine.

Areas where wilderness mapping schemes overlap in the Tarkine using Russell, Mathews & Jones (1979); Kirkpatrick & Haney (1980); Harries & Brown (1992); Lesslie & Maslen (1995); RNE (1997); Mendel (2002); North & Barker (2010).

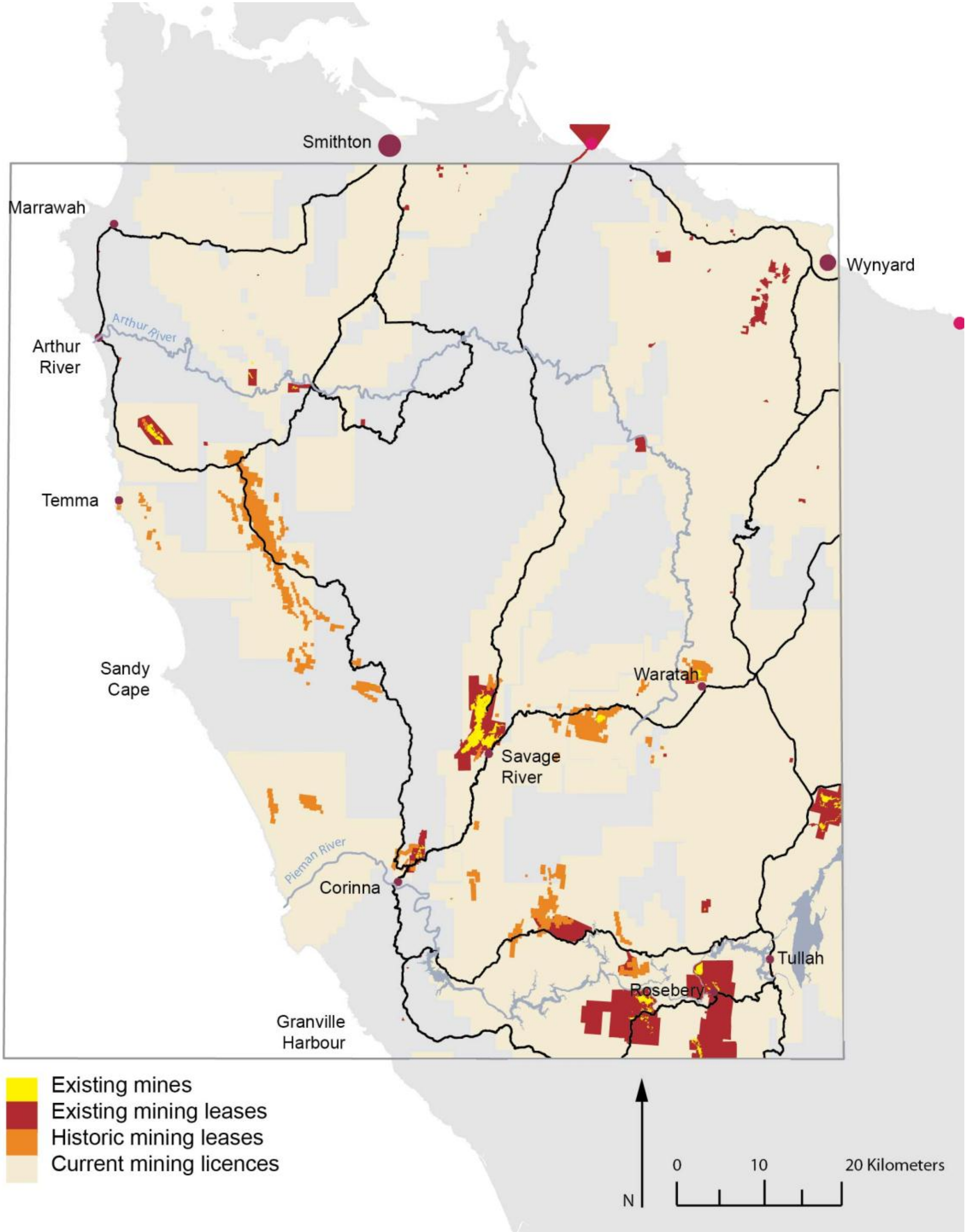


Figure 7.17 – Mining leases, licences and mines in the Tarkine.

Existing mining leases and licences (MRT 2013b). Historic mining leases 1881 to 1945 (Tasmanian Government 1881, 1891a, 1891b, 1892, 1894, 1898, 1900, 1911a, 1911b, 1911c, 1911d, 1911e, 1911f, 1911g, 1913, 1914, 1922, 1923, 1925, 1934, 1945).

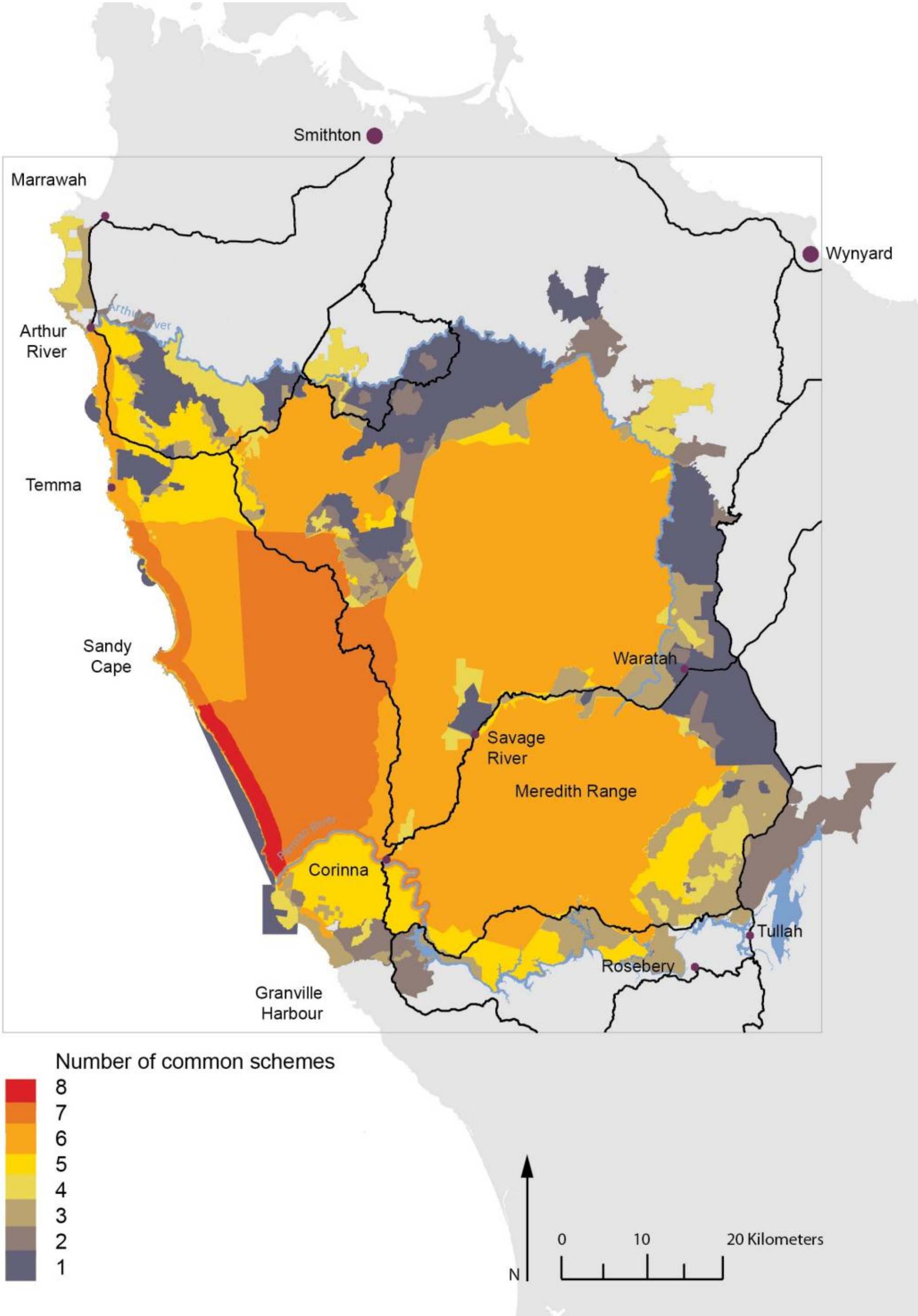


Figure 7.18 – Boundaries for the Tarkine area.

Areas where Tarkine place boundary schemes overlap using Circular Head Council (1969); RNE (1997); Cradle Coast Authority (2009); Tarkine National Coalition (2011); Australian Government (2011c); Tasmanian Government (2013b); Australian Heritage Council (2013); Australian Government (2013c).

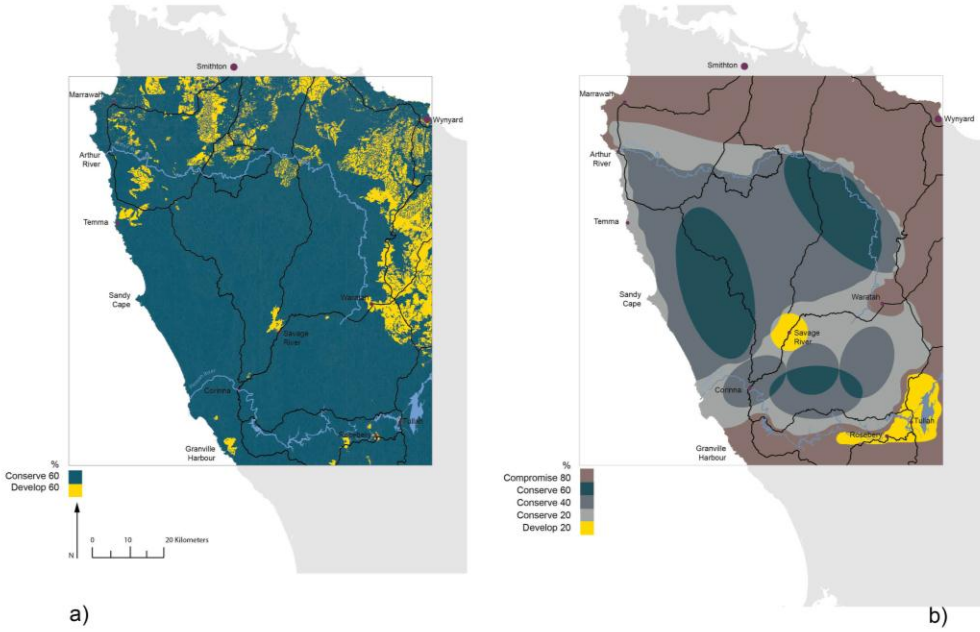


Figure 7.19 – Nature conservationist attitude group percentage of agreement.

(Attitude group level of agreement for a) selected maps and b) drawn maps).

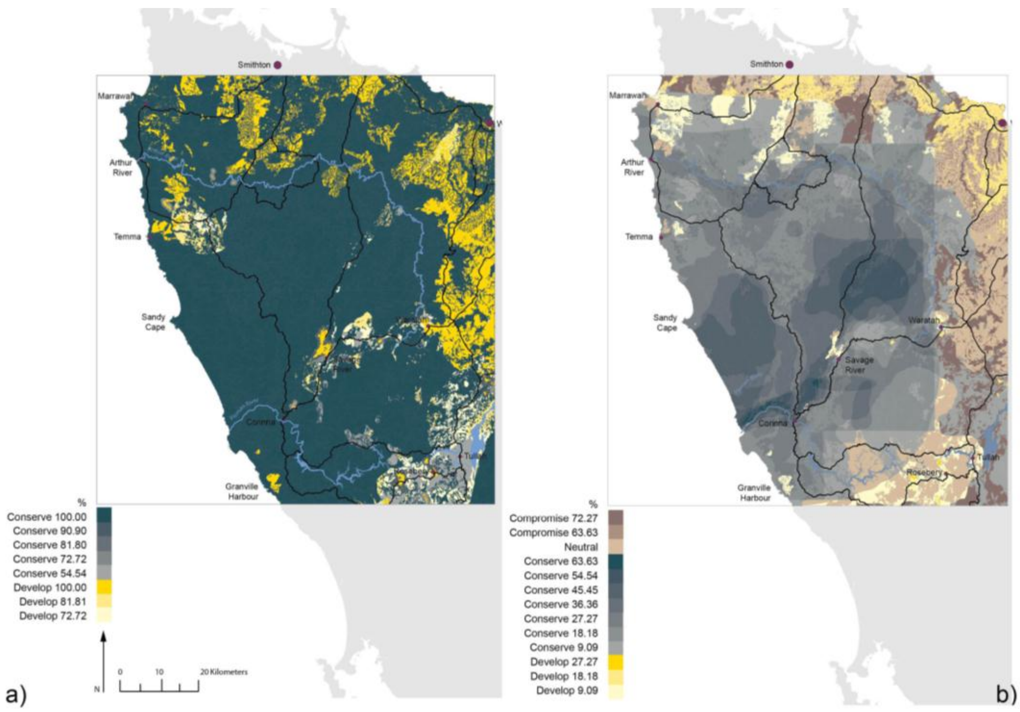


Figure 7.20 – Soft naturalists attitude group percentage of agreement.

(Attitude group level of agreement for a) selected maps and b) drawn maps).

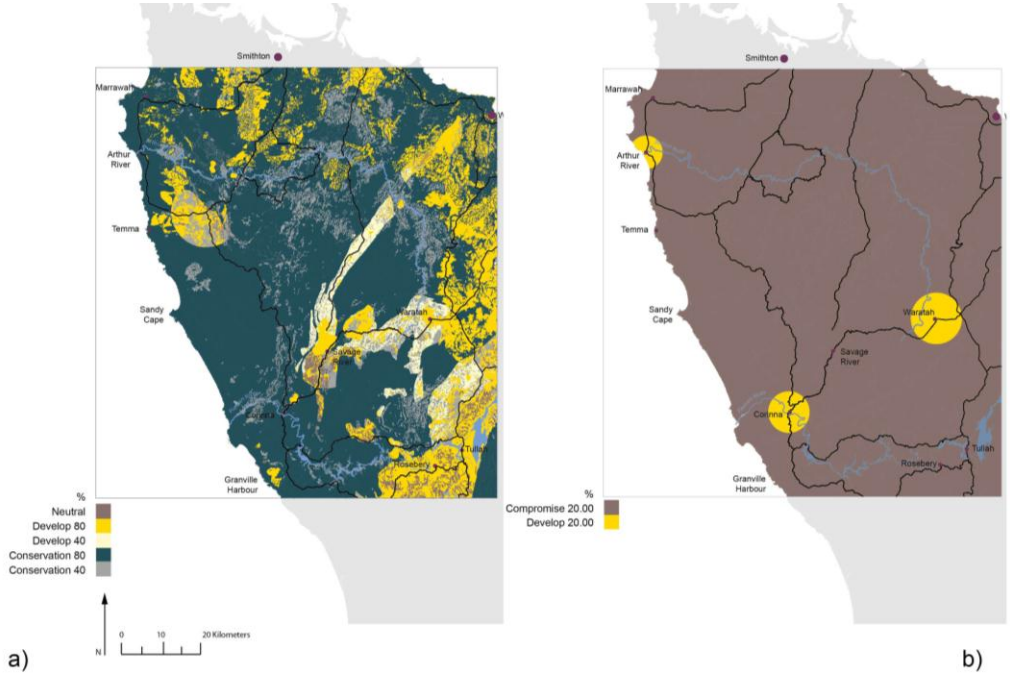


Figure 7.21 – Developers attitude group percentage of agreement.

(Attitude group level of agreement for a) selected maps and b) drawn maps).

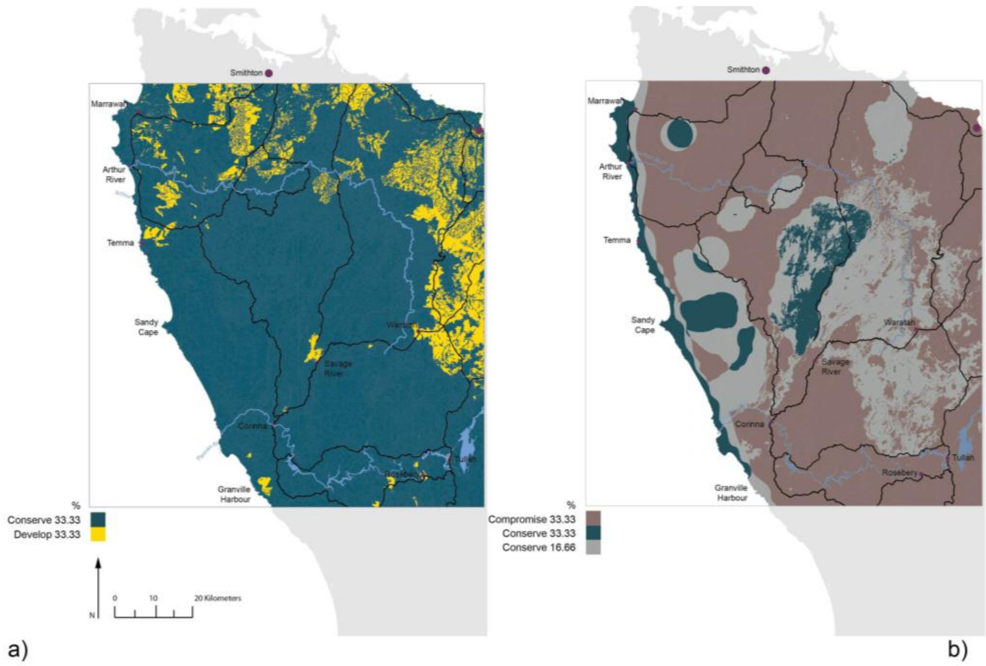


Figure 7.22 – Biocentrics attitude group percentage of agreement.

(Attitude group level of agreement for a) selected maps and b) drawn maps).

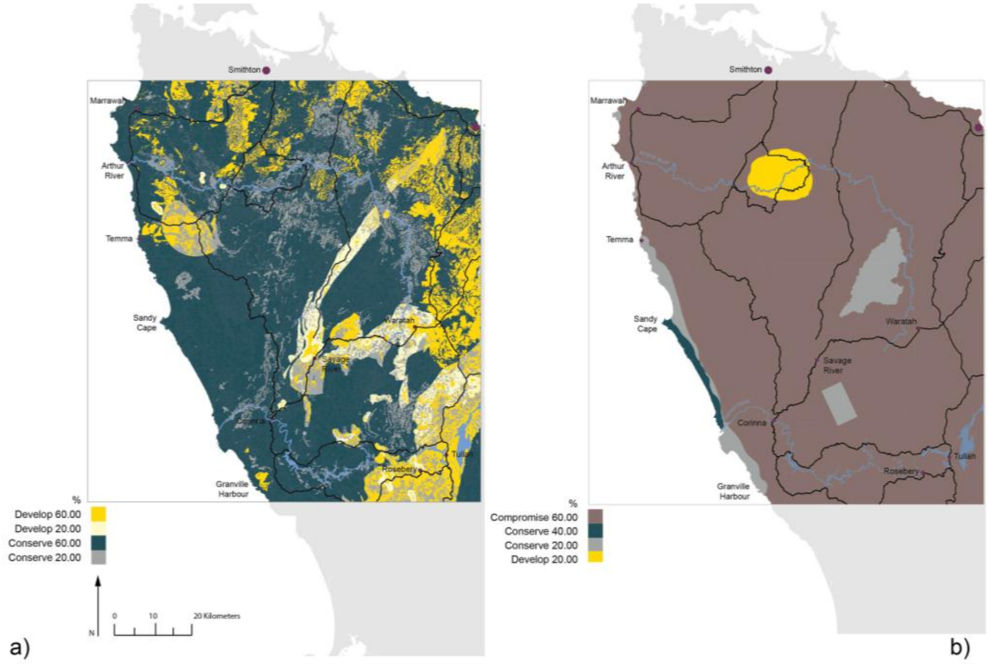


Figure 7.23 – Quiet compromisers attitude group percentage of agreement.

(Attitude group level of agreement for a) selected maps and b) drawn maps).

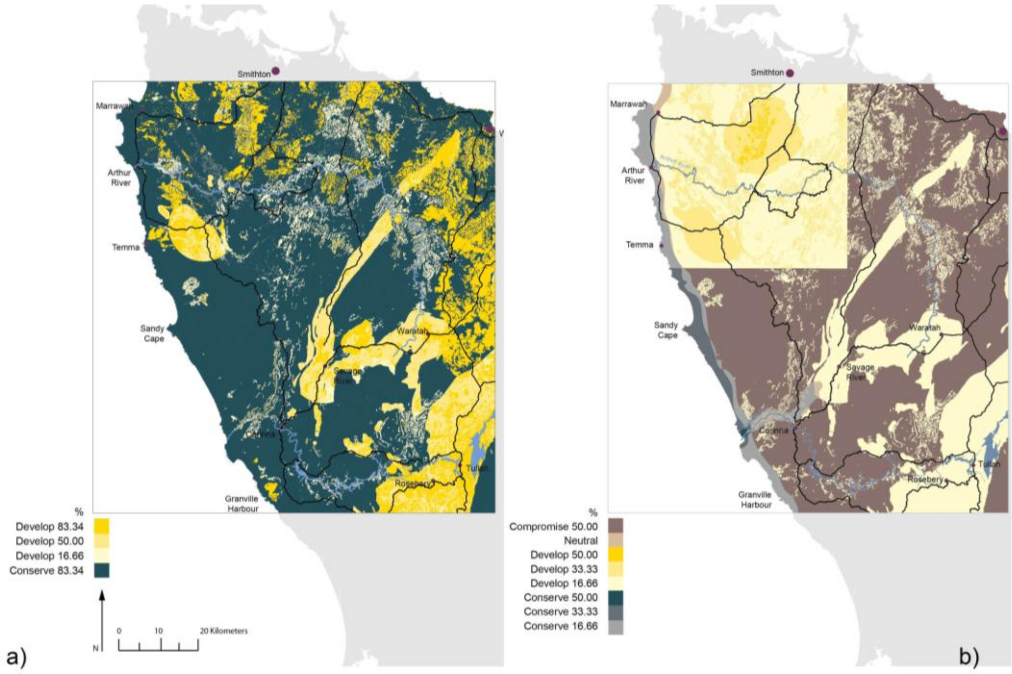


Figure 7.24 – Balanced developers attitude group percentage of agreement.

(Attitude group level of agreement for a) selected maps and b) drawn maps).

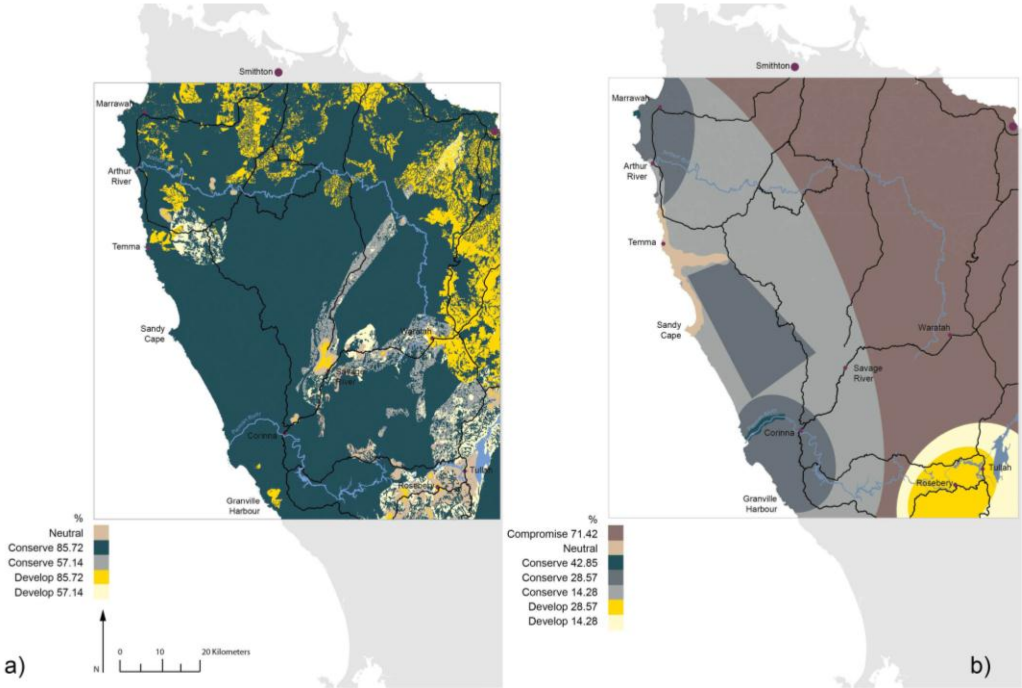


Figure 7.25 – Off-roaders attitude group percentage of agreement.

(Attitude group level of agreement for a) selected maps and b) drawn maps).